

**Wildfire Succession in Plant Communities
Natural to the Alkali Creek Vicinity,
Charles M. Russell National Wildlife Refuge,
Montana**

Prepared for:

U. S. Fish and Wildlife Service

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November, 2001



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USFWS AGREEMENT NUMBER 60181-0-J206

This document should be cited as:

Cooper, S. V. and C. Jean. 2001. Wildfire succession in plant communities natural to the Alkali Creek vicinity, Charles M. Russell National Wildlife Refuge, Montana. Unpublished report to the U. S. Fish and Wildlife Service. Montana Natural Heritage Program, Helena. 32 pp. plus appendices.

EXECUTIVE SUMMARY

Inventory was conducted in 2000 on the area burned by the Alkali Creek Fire in 1996 and adjacent comparable landscapes to identify plant associations, successional pathways and seral stages present. The study area encompasses highly convoluted terrain most of which is, or verges on, breaklands developed from erodible sedimentary parent materials. Thirteen plant associations are identified, of which two are provisional upland types described for the first time. The great majority of the landscape is dominated, or potentially dominated, by three upland matrix types: woodland, grassland, and much reduced in extent, a shrub herbaceous type. Relatively moist to wet environments comprise a small fraction of the landscape including seasonally or temporarily flooded coulee bottoms and alluvial fans and terraces.

Despite a four-year lapse between the Alkali Creek Fire and documenting fire's effects by vegetation type, alternative measures were used to distinguish the severity and intensity of the fire, mostly with regard to woodland stands. Burns in ponderosa pine (*Pinus ponderosa*) woodland stands rated as high intensity and generally stand-replacing. Moderate and low intensity fire regimes were also documented. Rocky mountain juniper (*Juniperus scopulorum*) is extremely fire-susceptible resulting in its mortality on all burned terrain. Fire severity appears to be positively correlated with burgeoning populations of increaser species (Society for Range Management 1999, cited in Pellant et al. 2000), undesirable aliens, and noxious weeds. Low intensity and severity fires favor species typical of later seral stages. Response of stands in which shrubs comprise an important component depends in large part on the evolved post-burn strategy of the component species with crown sprouters, such as black greasewood (*Sarcobatus vermiculatus*) and silver sagebrush (*Artemisia cana*), developing much more quickly to reestablish their pre-burn contribution. Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) is extremely fire-susceptible and has been eliminated over much of this landscape. Our impressions and literature-documented findings indicate that succession is slower in these habitats, at least in regards to re-establishing the sagebrush component, than has hitherto been appreciated. Fire in grassland vegetation types is seldom, if ever, stand-replacing; rather, it is difficult to gauge fire effects in grasslands without having a pre-burn inventory. In this landscape thickspike wheatgrass (*Elymus lanceolatus*) is ubiquitous, the grassland dominant and stimulated by fire (though first-year post-burn depression in production is possible) with doubling and tripling of cover (in at least some habitats) for the two to four years following burning. We speculate there has been a post-burn increase in the alien annual grass, Japanese brome (*Bromus japonicus*), which can be attributed to both the burn and possibly the build up of litter.

Though this type of landscape is not unique in geology or landform and does not contain any rare communities or species deemed to be of special concern, it is in excellent ecological condition with a minimum of weedy species. The Alkali Creek Fire probably was of greater extent than previous fires in this landscape and we speculate that certainly the number of woodland stands that experienced stand-replacing intensities was outside the natural range of variation. Permanent plots should be established to track the course of succession on the woodland and shrubland portions of this landscape.

ACKNOWLEDGEMENTS

Integral to this project were the coordination and information provided by Bill Haglan and the Geographic Information system (GIS) expertise of Steve Henry. The project also benefited from initial discussions with the forenamed and Bill Berg, all with the Charles M. Russell National Wildlife Refuge, Lewistown Office.

Whitney Weber (Montana Natural Heritage Program, MTNHP) designed and produced the study area map and Duane Lund (Natural Resource Information Systems, NRIS) did likewise for the shaded relief map. Cedron Jones, Martin Miller and Terrie Kenney (MTNHP) processed plant association records and in addition Terry entered information and photographic images into appropriate program databases. The report also benefited appreciably from our discussions with botanist Bonnie Heidel regarding the ecological and distributional context of study area plant associations. Thanks to Joy Lewis (MTNHP) for her editing and production help.

Though this report has profited from the support and contributions of many people, any errors of commission or omission rest with the authors. This project was supported by a challenge cost-share agreement between the U. S. Fish and Wildlife Service and the Montana Natural Heritage Program (USFWS Agreement Number 60181-0J206).

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INTRODUCTION

From the formative years of wildlife management, when the emphasis was on monitoring and regulating mortality and productivity for individual species, the breadth of endeavor has expanded to managing species' habitat, landscape and habitat processes, and the flora and fauna at large. The United States Fish and Wildlife Service (USFWS) adopted an ecosystem approach to fish and wildlife conservation in 1994, defined as "Protecting or restoring the function, structure, and species composition of an ecosystem, recognizing that all components are interrelated" (Martin 1996). The primary factors structuring ecosystems of the northern Great Plains are fire, herbivory (domestic or wild ungulates) (Sims et al. 1978) and strong climatic fluctuations (Weaver and Albertson 1944). Cooper and Heidel (1999) established through inventory that the Research Natural Areas (RNAs) established at the Charles M. Russell National Wildlife Refuge (CMR) harbor considerable ecological diversity, though only one of the areas captured a typical and extensive uplands landscape. The Refuge is important as it represents extensive and representative central Montana mixed-grass prairie (potential climax vegetation with mixture of mid- and short-grasses).

In 2000, the CMR and Montana Natural Heritage Program, through a challenge cost share agreement, completed an extensive inventory and assessment of plant community and successional patterns in Ponderosa Pine woodlands and mid-grass prairie in and around the 1996 Alkali Creek Fire. The Alkali Creek Fire, a natural lightning-caused ignition on Bureau of Land Management (BLM) land, was pushed by a wind out of the west, burning onto CMR. The fire's outer perimeter encompassed approximately 10,000 acres. The Alkali Creek Fire of 1996 provides a prime opportunity to specifically document ecosystem, and especially plant community, response to fire.

The goals of this study are:

- ◆ Identify vegetation communities (plant associations), biological features, and sites of ecological significance.
- ◆ Develop descriptive succession pathway models and written descriptions of disturbance response for large patch (50 to 2,000 ha) and matrix (2,000 to 500,000) community types. This approach was extended to include some small patch community types (tenths to 50 ha) occurring on specialized landform positions or in unusual microhabitats. This modification of the original intents of investigators was necessitated by the fact that a mosaic of small patches occupies a considerable portion of the study area landscape.
- ◆ Ground truth and correlate GAP vegetation cover type maps with plant associations of the National Vegetation Classification. GAP land cover is currently the only refuge vegetation data layer available to CMR personnel. Correlating the GAP cover with that of sampling points (ground verified) identified to plant association will enable an accuracy assessment the GAP layer and its usefulness for ecosystem management.

STUDY AREA

LOCATION

The study area (Figure 1) lies in the far northeastern corner of Petroleum County in North Central Montana. The area of focus is the Alkali Creek Fire of 1996 and the surrounding terrain. Some outlying stands were sampled on the Dovetail Trail, an area with sandstone parent material and extensive unburned

stands of ponderosa pine (*Pinus ponderosa*). This unburned condition was not present to any degree in the Alkali Creek focus area, the fire having consumed virtually all the sandstone-based stands. The study area is roughly bounded by the Drag Ridge Trail (Road 103), and spur Road 410 and Crooked Creek Bay (of Fort Peck Reservoir) to the north and Road 414 or Alkali Creek bearing southeast and on the west the Musselshell River and Musselshell Bay.

GEOLOGY AND SOILS

Following the U. S. Forest Service's National Hierarchical Framework of Ecological Units (ECOMAP 1993, Nesser et al. 1997) this landscape setting is, from the most specific level to increasingly coarse levels of description, the Missouri River Breaks Subsection (331Df) of the Northwestern Glaciated Plains Section (331D) of the Great Plains-Palouse Dry Steppe Province (331).

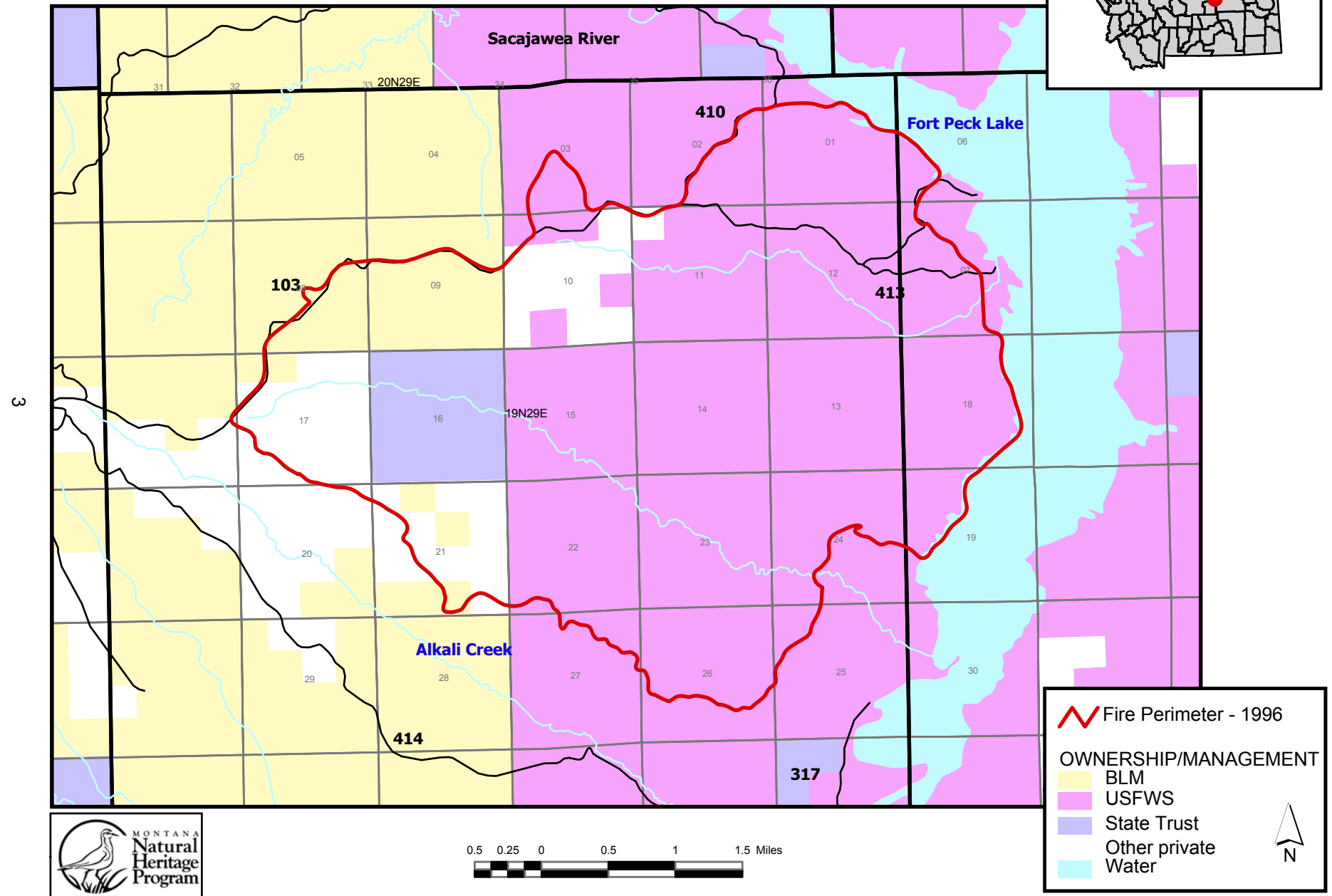
"The Breaks" is the landform referred to colloquially by local residents and occupies a significant portion of the study area (see Figure 2); it in fact has a specific geomorphic connotation, which is a tract of land distinct from adjacent land and characterized by marked variation of topography, such as an irregular or rough piece of ground (Haskins et al. 1998). The Breaks are extensive along the Missouri River and the most downriver portion of the Musselshell, before its confluence with Fort Peck Reservoir. The Breaks comprises an area where erosion has down cut clay shales, siltstones and sandstones. Erosion is actively cutting tributary valleys headward and downward to match the elevations of the area's major streams (Crooked Creek, also known as Sacajawea River, Alkali Creek, Drag Creek, Musselshell River). Steep and occasionally unstable slopes and narrow, incised stream channels characterize the Breaks. The lower reaches of the drainages are generally clogged because overloaded streams deposit sediments from the very rapid valley head erosion. This deposition has the effect of widening the lower valley segments and in places subsequent downcutting creates deep new channels in previously deposited alluvium. The geomorphic processes forming these breaklands reflect such seemingly insignificant events as a single torrential thunderstorm or a high-yielding spring runoff.

The prominent ridge of the Cat Creek Anticline running northwestward across the middle part of Petroleum County divides the county into two distinct geological regions; that to the north contains bedrock of either Bearpaw Shale or the Hell Creek Formation. The predominant lithology of the Hell Creek Formation, which overlies the gray to black marine shales of the Bearpaw Formation, is fine-grained sandstone. This sandstone, resistant in places, forms steep-sided cliffs, ridges as well as the escarpments and comprises the uppermost bedding planes of small mesas in the central portion of the study area. It is these weathering-resistant Hell Creek sandstones that cap the interfluvies between stream valleys that have been cut into Bearpaw Shale.

Though the Pleistocene continental glaciation is not known to have extended south of the current course of the Missouri River, what appears to be glacial drift or coarse outwash is scattered across the study area randomly, and is not it restricted to particular surfaces.

Of the 43 soil series mapped for Petroleum County, Montana (Lindahl 1993) thirteen of these are mapped within the study area (Table 1). At the order level, soils of these series are primarily young with little horizon differentiation. Entisols or Aridisols soils reflect the semi-arid climate by having reduced amounts of organic matter in the upper horizons. Vertisols, soils characterized by a high content of shrink-swell clays and vertical mixing, are represented by only two series but one, Bascovy, is a major component of four extensive mapping units (Table 1). Mollisols, typified by mollic epipedons, (a surface horizon extending at least 18 cm deep, darkened with organics and its exchange surfaces dominated by divalent cations) are represented by only one series, which is present in only one mapping unit. The lack of extensive Mollisols in this landscape is probably exactly why it has remained intact and has not been

Figure 1: Alkali Creek Fire study area.



the subject of agricultural development. Soils derived from Bearpaw Shale, those of the Bascovy, Neldore and Gerdrum series, cover large extents of this landscape; these are the most dissected areas of the landscape with steep slopes and actively eroding drainage heads and slopes. The weakly consolidated sandstones and shales of the Hell Creek Formation are the parent materials for the Cabbart-Delpoint-Rock-outcrop general soil map unit. This unit is associated with the “mini-mesas” in the west central portion of the study area, occupying their upper surfaces, steep escarpments and colluvial fans. These are primarily loamy (including fine sandy loams), well-drained soils on which the bunchgrass component, namely bluebunch wheatgrass (*Pseudoroegneria spicata*), needle-and-thread (*Hesperostipa comata*) and Sandberg bluegrass (*Poa secunda*), exhibit high coverage relative to those of the rhizomatous wheatgrasses which flourish on the heavy-textured soils derived from Bearpaw Shale.

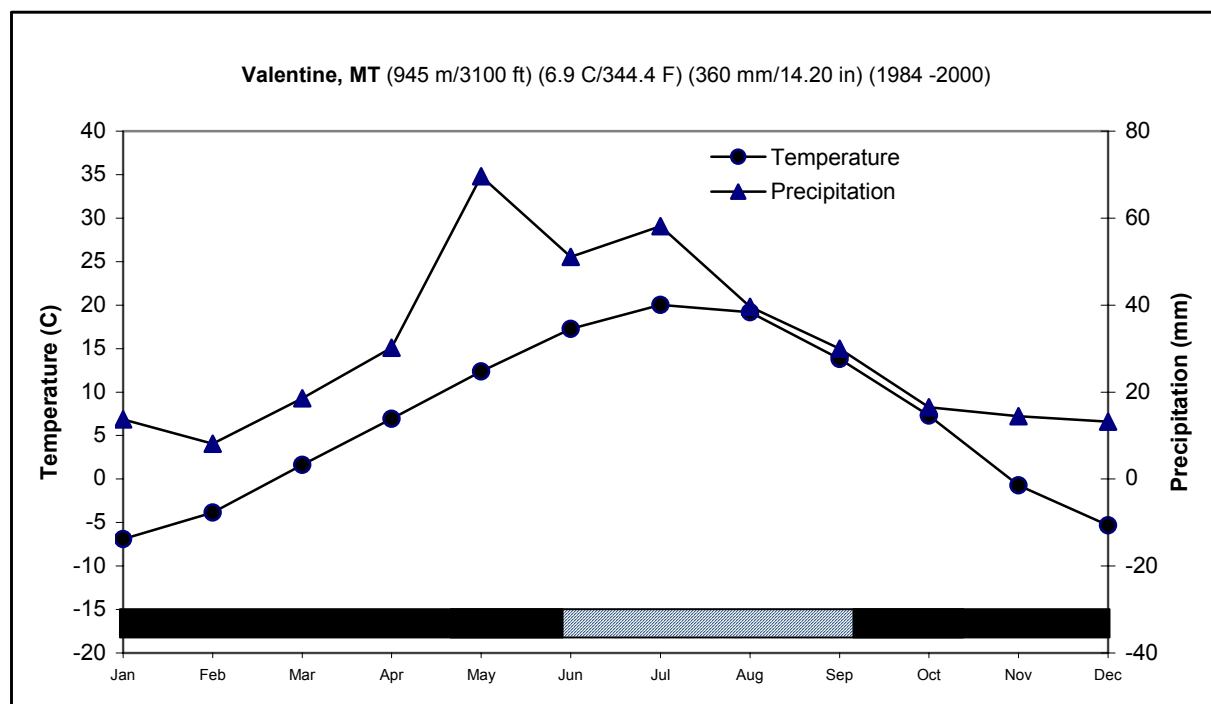
Table 1. Soils of the Alkali Creek Fire Study Area

Soil Series	Map Unit Designation	Family	Subgroup	Order
Bascovy	8; 9; 70; 64	Fine, montmorillonitic	Udorthentic Chromusterts	Vertisol
Blackhall	23	Loamy, mixed (calcareous), frigid, shallow	Ustic Torriorthents	Entisol
Cabbart	18; 23; 16; 32; 17	Loamy, mixed (calcareous), frigid, shallow	Ustic Torriorthents	Entisol
Creed	39;	Fine, montmorillonitic	Borollic Natragids	Aridisol
Delpoint	18; 98; 23; 16; 32; 98; 17	Fine, loamy, mixed	Borollic Camborthids	Aridisol
Ethridge	34;	Fine, montmorillonitic	Aridic Argiborolls	Mollisol
Gerdrum	39	Fine, montmorillonitic	Borollic Natragids	Aridisol
Harlem	43	Fine, montmorillonitic, frigid	Ustic Torrifluents	Entisol
Marvan	60	Fine, montmorillonitic, frigid	Udorthentic Chromusterts	Vertisol
Neldore	8; 9; 66; 70; 61; 64	Clayey, montmorillonitic nonacid, frigid, shallow	Ustic Torriorthents	Entisol
Vaeda	84	Fine, montmorillonitic, nonacid, frigid	Ustic Torriorthents	Entisol
Vanda	60	Fine, montmorillonitic (calcareous), frigid	Ustic Torriorthents	Entisol
Yamac	98; 32	Fine-loamy, mixed	Borollic Camborthids	Aridisol

CLIMATE / WEATHER

The study area is relatively limited in extent, and finely and shallowly dissected, which means there is little overall topographic (elevation) relief (about 580 feet); these observations argue for the macroclimate being fairly uniform across the area. The area has a semi-arid (precipitation of 12-14 inches), temperate continental climate, typified by a cold winter and hot summer with the bulk of precipitation coming in late spring-early summer, peaking in May (see Figure 3). Average daily minimum temperatures at the Valentine and Roy stations are respectively 5.9 and 3.4 degrees in January and the daily maximums in July are respectively 84.2 and 88.0.

Figure 3. Climate diagram showing average monthly temperature and precipitation. The hatched bar across the bottom shows growing season length or the number of frost-free days where the mean daily minimum temperature is above 0 degrees C. The title bar shows the weather station location, elevation, mean annual temperature, mean annual precipitation, and the period of observation.

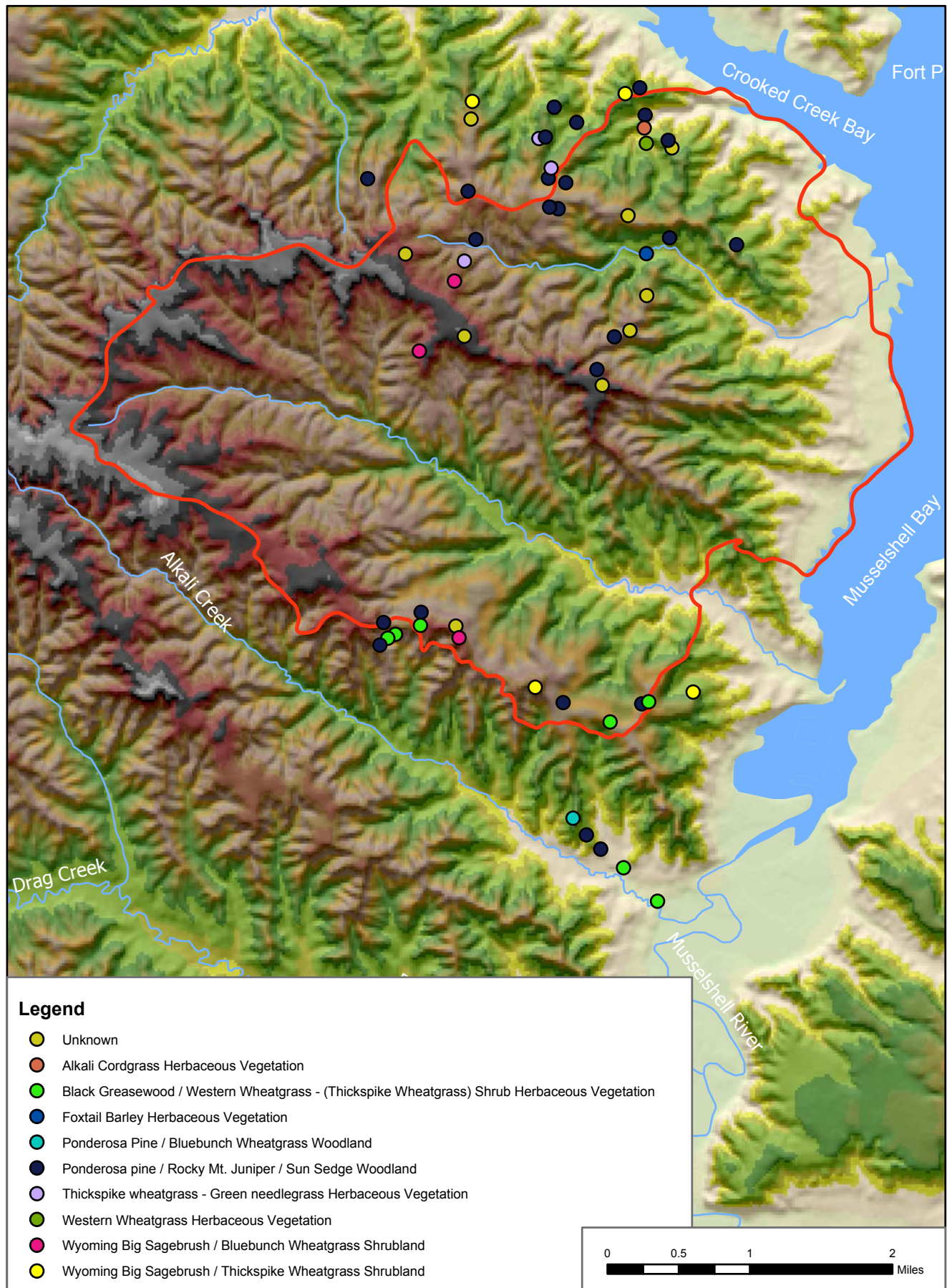


The study area, though set well within the Great Plains and exhibiting a strong contrast between summer and winter temperature typical of continental climates, does not have the predominance of summer precipitation found further to the east. For all reporting stations in the study area vicinity (Valentine, Grass Range, Winnett and Roy) between 49 to 51% of annual precipitation comes in a three-month period encompassing late spring to early summer. Depending on the station, May or June is usually the rainiest month. It is instructive to note this same spring deluge pattern is found in Western Montana, after which precipitation amounts fall off considerably in July-September. This contrasts with July through September study area precipitation, which averages from 0.5 to 1.0 inches more than do western Montana sites with the same total precipitation. Though this mid- to late-summer precipitation can come from frontal systems, it is more often the result of convection systems (thunderstorms), which deliver needed moisture, but can also result in lodging of herbaceous vegetation, denudation of shrubs, severe erosion events and lightning-caused fire.

Also typical of continental climates is significant year-to-year variation in precipitation. For example, at Redstone, Montana, one year in ten will have less than 8 or more than 18 inches annual precipitation (Richardson and Hanson 1977). Typically for this region two out of ten years exhibit extreme drought. These climatic fluctuations, particularly drought, have been characterized as constituting a major disturbance regime within the Great Plains environment (Nesser et al. 1997).

As in other semiarid environments, precipitation is the climatic factor with the greatest influence on plants and therefore plant communities and their production. In the study area, precipitation in May, June, July, the period critical to plant production, in the year preceding the Alkali Creek Fire of 1996 was considerably above normal, between 29% (Valentine Station) and 40% (Roy 8NE Station). In the fire

Figure 2. Alkali Creek Fire Study Area with Vegetation Sample Points



year of 1996, May precipitation was between 38 and 48% above normal and accompanied by cool temperatures, but the remainder of the summer was unusually dry with higher than normal temperatures. It is a reasonable hypothesis that this dry spell (May 1995 through Aug 1996) would have produced abundant fuels, and then extremely dry fuels and ultimately hazardous fire conditions due to extended high temperatures and the continuity and quantity of fuels. This scenario set the stage for the Alkali Creek Fire, which burned in a rather continuous fashion over the landscape.

The post-fire weather is also quite pertinent to this study. In the immediate post-fire year of 1997, precipitation in the critical May-July period was greater than the long-term average by 31 to 38% (depending on station cited) and then it fell off for the next three years by anywhere from 11 to 21%. The post-fire year should have been highly favorable for both the germination and establishment of ponderosa pine (*Pinus ponderosa*) and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) seedlings if the seed crop for the post-fire year were normal.

VEGETATION

Vegetation patterns primarily reflect differences in geology (parent material) and topographic position and secondarily, soil variation and disturbance (fire, grazing and drought). The majority of the area on flats and warmer exposures is characterized by steppe vegetation, both graminoid-dominated and graminoids with a conspicuous shrub layer (though with not enough cover to constitute a shrubland as defined by the National Vegetation Classification Standard). Steppe is temperate zone vegetation dominated by graminoids and occurring in climates where zonal soils are too dry to support trees. Most of the grassland is developed on heavy-textured, shale-derived soil and is dominated by the wheatgrasses, thickspike wheatgrass (*Elymus lanceolatus*) on the uplands and western wheatgrass (*Pascopyrum smithii*) on bottomland positions with a higher moisture status. Other grass-dominated vegetation is associated with the narrow riparian zones and pan spots of the uplands.

At least in regard to the uplands, the very same positions and soils typified by grasslands are also occupied by varying densities of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), though this sagebrush occupies a much smaller fraction of the landscape than does grassland. While subtleties in soil parameters may partially explain this differential distribution, a much more likely cause is past fire. There are indications that the fire intolerant Wyoming big sagebrush will very slowly establish on areas where it has been extirpated by fire. For instance, in the course of the study area inventory not a single Wyoming big sage seedling was found in any of the areas that had burned in the Alkali Creek Fires of 1996. The lack of seedlings is not readily explainable; certainly sagebrush was severely reduced in abundance by fire but any number of populations, both within and outside the fire perimeter, remained and set seed. This lack of post-fire establishment of Wyoming big sagebrush conforms to the results found for control burns of this taxon. In southwestern Montana Wambolt and Payne (1985) found no re-establishment of Wyoming big sagebrush 6 years following burning and in 18 years its canopy cover was still less than 2% compared to as much as 16% in other treatment types. For southeastern Idaho Murray and Harniss (1973) report that Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) establishment and production is very low for the initial 12 years following burning.

The only other extensive vegetation type with a conspicuous shrub component is the black greasewood (*Sarcobatus vermiculatus*) scrub, associated with sites slightly- to highly-sodic (high sodium content) to saline. The cover of black greasewood is usually considerably less than 20-25% to as low as 5%, however, communities of this relatively tall shrub when viewed obliquely give the impression of greater canopy cover. This vegetation type is most extensively developed on alluvial fans and floodplains of the Musselshell River and Crooked Creek but also extends upslope if soil conditions are favorable (high sodium). Also noted along Musselshell River and Crooked Creek were stands of silver sagebrush

(*Artemisia cana*) still dominated by western wheatgrass (*Pascopyrum smithii*), but with undergrowth of disturbance-responding species.

A considerable fraction of the study area supports patches of ponderosa pine (*Pinus ponderosa*)-Rocky Mountain juniper (*Juniperus scopulorum*) woodland; these individual stands of trees, separated from the next stand of trees by less than a tenth of a mile in most cases, are considered collectively to constitute a matrix type of vegetation. Stand structure characteristically exhibits a very open canopy, often with less than 40% canopy cover, of 20-45 feet tall ponderosa pine over scattered, short-stature Rocky Mountain juniper. Only in the oldest stands (> 180-200 years) that have not experienced under-urns for an extensive period does Rocky Mountain juniper cover approach amounts that could define a separate layer. Even more unusual are stands whose canopy is dominated by Rocky Mountain juniper alone. Conventionally all of the above-described stands occur as small patches, confined to steeper slopes with cooler exposures facing north to northeast, but occurring on other exposures if compensating factors are operative. A very small fraction of these stands occur on lighter-textured soils derived from sandstone or sandstone mixed with finer-textured sedimentary materials. When occurring on these better drained parent materials ponderosa pine occupies a wider range of aspects ostensibly due to the fact that water percolates more deeply, possibly into rock fractures or soil beyond the drying front, where it can be tapped by this deeply rooted pine.

METHODS

To sample for important and significant biological features, most particularly natural plant communities in one abbreviated field season, an effective environmental stratification was needed as an index to the range of habitats present. The scale of the state geology map proved to be too small to effectively use at this project level, but the Petroleum county soil survey map and mapping units, which are strongly associated with geological substrate and landform, proved more than adequate. Soil survey maps are also convenient because their scale (1:24,000) corresponds to that of the U.S. Geological Survey topographic maps used as base maps to record observations. We used soil series descriptions and their presence in mapping units to locate the most accessible of particular parent material types, which are hypothesized to strongly condition vegetation response.

From previously conducted field inventory on the refuge (Cooper and Heidel 1999) and reports addressing regional vegetation (Culwell and Ramsden 1972; Harvey 1982; Mackie 1970; Roberts 1977; Roberts et al. 1979;) we compiled a preliminary list of plant associations that were known or hypothesized to occur within the study area. We also evaluated the distribution and rarity of plant associations to prioritize them for survey.

We designed the vegetation sampling to characterize:

- ◆ Examples of common plant associations in good condition;
- ◆ Plant associations of potential statewide or rangewide rarity and significance;
- ◆ Provisional new plant associations or ones not previously known from the study area vicinity;
- ◆ Patterns of seral response in regard to fire and for woodlands specifically trying to model how burn intensity affects succession and structures post-fire communities.

For plant associations we documented species composition, structure, and associated abiotic environmental parameters. The ecology plots were placed to represent homogeneous natural vegetation and uniform environmental conditions across the plot. We employed 1/10 acre circular plots (37.2 ft. radius) to document species composition by canopy cover classes (Daubenmire 1952). Because the fine scale of dissection was incapable of being captured on a 1:24,000 scale topographic map, the landscape is a patchwork of communities. Using a standard 1/10-acre plot necessitated careful plot placement (or in

some cases deviating from the circular configuration to a linear form) to sample a homogeneous environment or plant community. To obtain an estimate of population structure for tree cover, values were recorded for trees by diameter classes (seedlings, 0 to 1"; pole, >1 to 5"; mature, >5-9"; large mature, >9-18"; over mature, >18").

Occasionally when inventorying a post-burn condition in a formerly wooded stand, a mosaic of post-burn communities would be present that were not attributable, in our estimation, to differences in fire severity. Doubling plot size and averaging conditions over this greater area accommodated this condition. Another sampling problem was obvious differences in fire severity (and hence response) within a given stand over subplot distances, in which case we attempted to describe an average condition. For unburned stands a dominant tree (or trees) representing the oldest age-class was cored near the base (< 1 foot from ground) to obtain an estimate of stand age or time since stand initiation.

An attempt was made to characterize the severity of the burn within a stand or within a given plot when intra-stand burn severity varied considerably (often the case). Severity of fire reflects (1) the immediate or primary effects of fire that result from the intensity of the propagating fire front and (2) heat released during total fuel consumption. Intensity (rate of heat released per unit area) is reflected in and commonly measured by flame length classes or by observing scorch height and then calculating flame length (Ryan and Noste 1983). In the four years following the burn neither of these variables (flame length or scorch height) were capable of being evaluated; flame length for obvious reasons and scorch height because of subsequent bark and needle sloughing. Fire-induced mortality by size classes was employed as a measure of the aboveground heat pulse. The downward heat-pulse (termed ground char) relates to factors other than intensity, specifically a categorization of post-burn soil and fuel features (Ryan and Noste 1983). All post-fire soil and fuel features, for example ash color, depth of charring, degree of recognizable plant remains, have been long obliterated; we substituted post-fire undergrowth vegetation survival, recovery and differential response as an index of severity. Notes were also kept regarding fire scarred trees within wooded stands both burned and unburned.

Canopy cover values by species, environmental descriptors, and plot location were recorded on a survey form that was subsequently entered into a permanent electronic database. Following data entry, plots were stratified by dominant lifeforms and by burned versus unburned and then run through pertinent vegetation keys (Roberts et al. 1979; Mueggler and Stewart 1980; DeVelice et al. 1995; Hansen and Hoffman 1988; Hanson et al. 1995). Plots were also compared to descriptions of plant associations and community types for this region (references cited above) and to descriptions contained in a national database (ABI, 2001) and then assigned to plant associations or other types of plot assemblages.

The unburned areas within the fire perimeter served as the source of control plots for these descriptions. In some cases, such as for the ponderosa pine / bluebunch wheatgrass (*Pinus ponderosa* / *Pseudoroegneria spicata*) association that occurs on sandstone rimrocks, we had to locate unburned examples outside the fire perimeter as all stands (sufficiently large to sample) within the fire's perimeter had been burned.

Plots not consonant with existing plant association descriptions constituted the raw material for defining new plant associations. We followed the precepts of the National Vegetation classification System (NVCS; Grossman et al. 1998) in aggregating the plots into new plant associations. The NVCS is a system that is defined in terms of recurring vegetation attributes. The system:

- ◆ Emphasizes natural existing conditions (not based on potential natural vegetation);
- ◆ Uses a classification hierarchy based on structure and floristic composition;
- ◆ Identifies vegetation units based on both quantitative and in some cases qualitative data;

The NVCS classification is hierarchical, combining floristics at the lowest levels, association and alliance, and emphasizing stand physiognomy and regional climate conditions at the highest levels. The plant association is defined in terms of the dominant or diagnostic species in the uppermost vegetation layer and any co-dominant species, diagnostic species, or the dominant species of subordinate vegetation layers. Literature review and stand data analysis has been conducted in Montana to produce an initial working list of the state's plant associations.

Our principle floristic references for specimen identification were Dorn (1984), Great Plains Flora Association (1977, 1986), Hitchcock and Cronquist (1973). Looman (1982) was consulted for identification of grasses in the vegetative state. Nomenclature adopted in this report is generally consistent with the above-cited references, except for revised taxonomic treatments that follow Kartesz (1994), concerning principally the grasses. Accepting the Kartesz (1994) treatment results in referring to some common dominant and indicator species, particularly the wheatgrasses (*Agropyron* and *Elymus* in the traditional sense) and needlegrasses (formerly *Stipa*), with unfamiliar sounding names. Consequently, western wheatgrass, termed *Agropyron smithii* in Booth (1950) and *Elymus smithii* in Dorn (1984), is herein referred to as *Pascopyrum smithii*. Synonymous names of dominant and indicator are cross-referenced in Table 2. Each species is also cross-referenced by both scientific name and common name the first time the species is mentioned under each heading in the text. Common names are based mainly on the list developed by the U. S. Forest Service of Region 1, which is mostly consistent with regional floras.

Table 2. Synonymy of scientific names for indicator and characteristic plant species (alphabetically arranged in 2nd column).

Common name	In: Booth (1950), (1966) or Great Plains Flora Assoc. (1986)	In: Dorn (1984)	In: Kartesz (1994)
Thickspike wheatgrass	<i>Agropyron dasystachyum</i>	<i>Elymus lanceolatus</i>	<i>Elymus lanceolatus</i>
Western wheatgrass	<i>Agropyron smithii</i>	<i>Elymus smithii</i>	<i>Pascopyrum smithii</i>
Little Bluestem	<i>Andropogon scoparius</i>	<i>Schizachyrium scoparium</i>	<i>Schizachyrium scoparium</i>
Bluebunch Wheatgrass	<i>Agropyron spicatum</i>	<i>Elymus spicatus</i>	<i>Pseudoroegneria spicata</i>
Narrow-leaved Sedge	<i>Carex eleocharis</i>	<i>Carex stenophylla</i>	<i>Carex stenophylla</i>
Sun or Long Stolon Sedge	<i>Carex heliophila</i>	<i>Carex pensylvanica</i>	<i>Carex inops</i> ssp. <i>heliophila</i>
Inland Saltgrass	<i>Distichlis spicata</i> var. <i>stricta</i>	<i>Distichlis stricta</i>	<i>Distichlis spicata</i>
Few-headed Spikerush	<i>Eleocharis pauciflora</i>	<i>Eleocharis pauciflora</i>	<i>Eleocharis quinueflora</i>
Shrubby Cinquefoil	<i>Potentilla fruticosa</i>	<i>Potentilla fruticosa</i>	<i>Pentaphylloides floribunda</i>
Silver-leaved Scurfpea	<i>Psoralea argophylla</i>	<i>Psoralea argophylla</i>	<i>Pediomelum argophyllum</i>
Lemon Scurfpea	<i>Psoralea lanceolata</i>	<i>Psoralea lanceolata</i>	<i>Psoralidium lanceolatum</i>
Slender-flowered Scurfpea	<i>Psoralea tenuiflora</i>	<i>Psoralea tenuiflora</i>	<i>Psoralidium tenuiflorum</i>
Green Needlegrass	<i>Stipa viridula</i>	<i>Stipa viridula</i>	<i>Nassella viridula</i>
Sea Blite	<i>Suaeda depressa</i>	<i>Suaeda calceoliformis</i>	<i>Suaeda calceoliformis</i>

RESULTS

ECOLOGICAL FEATURES OF SIGNIFICANCE

The entire Alkali Creek study area is a premier landscape that exemplifies sedimentary plains having planar features broken by extensive breaklands. Except for the gentle rolling plains in the far western portion of the study area, the topography is characterized as a badland landscape. Geomorphologists' define badlands as intricately stream-dissected topography having a very fine drainage network with high drainage densities and short steep slopes with narrow interfluves. Unlike other badlands in Montana (Terry and Bitter Creek Badlands) that support sparse vegetation, the Alkali Creek badlands are naturally more vegetated.

PLANT COMMUNITY DESCRIPTION

We documented the diversity of natural vegetation within the study area and clarified its distribution and significance within the context of the Northern Great Plains. We describe 13 plant associations. Table 3 conveys the global and state ranks and state distribution so that the association's degree of rarity and distribution can be appreciated at a glance. We describe here for the first time a ponderosa pine – rocky Mountain juniper / sun sedge (*Pinus ponderosa* – *Juniperus scopulorum* / *Carex inops* ssp. *heliophila*) association, which vied with grasslands as the most extensive pre-burn vegetation type. Though similar in some regards to existing types, this community appears to be sufficiently different to be considered unique. In addition, the importance of Rocky mountain juniper (*Juniperus scopulorum*) with rhizomatous wheatgrasses is also notable because it exhibits great structural diversity within this plains landscape. We also established that several associations, recently described for locations further east in Montana, are in fact more broadly distributed and constitute important components of Montana's prairie landscape. This information provides the basis for updating and documenting plant association status ranks and for expanding and refining the Montana vegetation classification as a whole.

Plant community descriptions, organized by the National Vegetation Classification Standard are presented in Appendix A. Plant Association descriptions are taken from the International Classification of Ecological Communities maintained by the Association for Biological Information (ABI) and updated by state Natural Heritage programs. A few plant associations are recently described by Montana Natural Heritage Program but, have not yet received regional recognition and are not yet included in the National Classification, or are state **provisional**, meaning they await further documentation before being submitted for regional and national acceptance into the National Classification. These associations, not recognized at the national level, are described from both literature sources and Montana-specific data and are recognized by the identifier label beginning with the prefix CEGLMTHP. **NOTE:** Within the **ELEMENT CONCEPTS** section of each plant association description in Appendix A, the **Dynamics** subheading contains more specific information than is provided in the immediately following "Response of Natural Communities to Fire" regarding successional processes and most especially observations distinctive to CMR fire succession.

RESPONSE OF NATURAL COMMUNITIES TO FIRE

A primary emphasis of this project was to determine successional patterns for the component plant associations, emphasizing those that have the greatest areal extent within the landscape. The Alkali Creek Fire provided the setting to evaluate a stand replacement event in ponderosa pine and Rocky Mountain

juniper woodlands and the transition to early seral herbaceous communities that now dominate the landscape. For the newly described extensive matrix type, ponderosa pine – Rocky Mountain juniper / sun

Table 3. Summary matrix of Plant Associations described from the Alkali Creek Fire study area

Plant Associations	Element Code	GRank	Srank	States	Pattern Type ¹ .
Woodlands and Forests					
<i>Juniperus scopulorum</i> / <i>Elymus lanceolatus</i> Woodland (Rocky Mountain juniper / Thickspike wheatgrass)	CEGLMTHP72	G?	S?	MT	Small Patch
<i>Pinus ponderosa</i> - <i>Juniperus scopulorum</i> / <i>Carex inops</i> ssp. <i>heliophila</i> Woodland (Ponderosa pine - Rocky Mountain juniper / Sun sedge)	CEGLMTHP71	G3?	S3	MT	Matrix
<i>Pinus ponderosa</i> / <i>Pseudoroegneria spicata</i> Woodland (Ponderosa pine / Bluebunch wheatgrass)	CEGL000865	G4	S4	WA, MT, OR, SD, BC, WY, ID, ND	Small Patch
SHRUBLANDS AND SHRUB HERBACEOUS VEGETATION					
<i>Artemisia cana</i> / <i>Pascopyrum smithii</i> Shrubland (Silver sagebrush / Western wheatgrass)	CEGL001072	G4	S4	MT, ND, NE, SD	Linear, Small Patch
<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> / <i>Elymus lanceolatus</i> ssp. <i>albicans</i> Shrub Herbaceous (Wyoming big sagebrush / Thickspike wheatgrass)	CEGL001044	G4	S4?	CO, MT, WY	Matrix
<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> / <i>Pseudoroegneria spicata</i> Shrub Herbaceous Vegetation (Wyoming big sagebrush / Bluebunch wheatgrass)	CEGL001009	G5?	S3	NV, MT, UT, ND, CO, BC, WY, ID, WA	Small Patch
<i>Sarcobatus vermiculatus</i> / <i>Pascopyrum smithii</i> – (<i>Elymus lanceolatus</i>) Shrub Herbaceous (Black greasewood / Western wheatgrass – (Thickspike wheatgrass))	CEGL001508	G4	S4	MT, NE, SD, WY, SK, ND	Matrix, Small Patch
<i>Symphoricarpos occidentalis</i> Shrubland (Western snowberry)	CEGL001131	G4G5	S4S5	CO, IA, MB, MT, ND, NE, SD, SK, WY	Small Patch, linear
HERBACEOUS VEGETATION					
<i>Elymus lanceolatus</i> - <i>Nassella viridula</i> Herbaceous Vegetation (Thickspike wheatgrass - Green needlegrass)	CEGLMTHP57	G4?	S3?	MT	Matrix
<i>Hordeum jubatum</i> Herbaceous Vegetation (Foxtail barley)	CEGL001798	G4	S4	SK, SD, ND, CO, MT	Linear
<i>Pascopyrum smithii</i> Herbaceous Vegetation (Western wheatgrass)	CEGL001577	G3G5?	S4	MT, UT, ID, CO, WY, SK, NE	Linear
<i>Pseudoroegneria spicata</i> - <i>Pascopyrum smithii</i> (<i>Elymus lanceolatus</i>) Herbaceous Vegetation (Bluebunch wheatgrass - Western wheatgrass (Thickspike wheatgrass))	CEGLMTHP73	G4	S4	MT, WY	Small Patch
<i>Spartina gracilis</i> Herbaceous Vegetation (alkali cordgrass)	CEGL001588	GU	S1S3	CO, WY, WA, MT, UT	Linear

¹ The pattern type refers to how the association occurs on the landscape as a small patch, large patch or as a matrix.

sedge (*Pinus ponderosa* – *Juniperus scopulorum* / *Carex inops* ssp. *heliophila*), we observed vegetation responses that appeared strongly conditioned by fire intensity/severity. It appears that the Alkali Creek Fire was, for the most part, stand-replacing in regard to woodlands and wholly stand-replacing for Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). These are noteworthy observations, based on stand structure, stand age and fire scar evidence, for a landscape that had not registered such a fire of such magnitude in many years, perhaps hundreds (however, many smaller fires have occurred throughout the years).

Why the Alkali Creek Fire was, for the most part, stand replacing and previous fires in this vicinity were not, is not well understood but remains an essential question. It should be appreciated that stand-replacing fires, or at least fires of high severity, set up the landscape for repeat fires by virtue of the flush of nitrates that stimulates the increased production of both introduced annual and native grasses and causing mortality in competing shrubs and trees. Drawing an analogy with what has occurred within the Great and Columbia Basins with regard to cheatgrass (*Bromus tectorum*) population explosions, once Japanese brome (*Bromus japonicus*) becomes a component of the vegetation, then subsequent fires, especially the hotter, higher severity burns, will favor its proliferation. This scenario could be forestalled by running surface fire through established ponderosa pine-dominated communities at intervals that would correspond to those experienced prior to the arrival of Euro-American man.

Without having a fire history study for this area, we suspect that since such a large fraction of the woodlands experienced stand replacing fire, that the Alkali Creek fire may constitute a disturbance event outside the natural range of variation. Though it is not possible to know exactly how this fire compares to past fires, we can say that the fire had a major impact on this landscape. Within the ponderosa pine stands study area fire effects were of severe intensity in slightly more than 50% of the cases and predominantly stand-replacing in more than 80% of the stands. Some stands did not experience a burn of such severity as to consume all of the fine branches in the crowns, but yet virtually all the trees were killed, certainly all the junipers. Many of these stands had not experienced a fire of such intensity in more than 200 years (based on age extrapolated from diameters of largest trees) and at least two stands were estimated to be over 300 years old extrapolating from diameters of the largest standing dead trees (dead prior to Alkali Creek fire). Stands composed predominantly of Rocky Mountain juniper invariably burned with high intensity and stand-replacing effects.

Where fire intensity and with total canopy mortality and severity was concomitantly high, the native graminoids were partially replaced with introduced grasses, principally Japanese brome (*Bromus japonicus*), increaser forbs (prickly lettuce (*Lactuca serriola*), pepperweed (*Lepidium* spp., and tansymustard (*Descurainia* spp.) and noxious weeds, primarily Canada thistle (*Cirsium arvense*). Preliminary observations indicate, even in the immediate vicinity of ponderosa pine or Wyoming big sagebrush stands, no post-fire regeneration of these species, despite at least one favorable year for establishment. Without a shade-casting tree and shrub canopy the increaser species are capable of persisting. Japanese brome (*Bromus japonicus*) is the one putatively negative feature within the study area landscape and that is because post-fire burgeoning populations of this alien grass create an early drying fuel source that predisposes the landscape to repeat burns.

Of the sixteen noxious weeds listed for Petroleum County (INVADERS Database, Rice 2001), only six, Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), spotted knapweed (*Centaurea maculosa*), leafy spurge (*Euphorbia esula*), perennial sowthistle (*Sonchus arvensis*) and common burdock (*Arctium minus*) were found within the study area. Locating and documenting study area weed populations was not a focus of this study, rather it was purely opportunistic, associated with establishing species inventories for plots. We located one patch each of spotted knapweed and perennial sowthistle; the knapweed was eradicated (ostensibly, at least the visibly rosettes) by hand pulling from its roadside position. Canada thistle was the only weed with a broad distribution, being consistently found in the

moderately and severely burned woodlands and only here. Bull thistle was also associated with severely burned sites but populations consisted of only a few individuals. Leafy spurge appeared to be associated with the lowlands in the vicinity of the Musselshell and Sacajawea Rivers (populations cursorily observed) and was not found in upslope positions, though certainly there is abundant appropriate habitat. A similar upright, but nonweedy spurge, Rocky Mountain spurge (*Euphorbia robusta*, tentative identification) was found in small patches associated with burned stands.

DISTURBANCE & SUCCESSIONAL PATTERNS

ROCKY MOUNTAIN JUNIPER SHRUBLANDS

In general, Rocky Mountain juniper stands have an open tree canopy cover and have a robust cover of grasses beneath the trees. This herbaceous undergrowth, in combination with the highly flammable bark and resin of the juniper trees, introduces Rocky Mountain juniper stands to intensive, hot burns that almost always completely kill and thoroughly incinerate the tree component (to the point that only charred stumps remain as evidence of pre-burn conditions). Following fire, the graminoid cover apparently increases, particularly that of thickspike wheatgrass (*Elymus lanceolatus*), whose post-fire cover can exceed 70%. Other graminoides present on these hot burns include green needlegrass (*Nassella viridula*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). In addition, Japanese brome (*Bromus japonicus*) is considerably stimulated to produce greater tiller density (higher cover) for as many as four years following the fire.

Moderate intensity burns in Rocky Mountain juniper were identified as having juniper snags with limbs remaining in part. These burns evidenced a much lower cover of Japanese brome (relative to hot fires) but the grasses cited for the hot burn were all present in the same coverage. In addition, sun or long stolon sedge (*Carex inops* spp. *heliophila*) was present in moderate amounts (4-20 % canopy cover). We speculate this sedge was extirpated within the hot fires and their immediate vicinity and would have to re-colonize these sites from adjacent populations. Note that sun sedge is not extirpated within hot fires in ponderosa pine stands; this differential response may be due to the greater heat pulse transmitted to the ground surface because the crown fuel in Rocky Mountain juniper is much closer to the ground. Yellow sweet clover (*Melilotus officinalis*) was the only forb present (0.5 to 17%) in all post-burn sites and evidenced no obvious response to fire intensity. Prickly lettuce (*Lactuca serriola*) had high cover on one plot and there were no noxious weeds recorded on any of these burned areas. Neither tree nor shrub seedlings were found on any of the burned plots, but scattered black greasewood (*Sarcobatus vermiculatus*) specimens were noted sprouting from root crowns.

We speculate for the reasons enumerated in the first paragraph of this section that Rocky Mountain Juniper seldom, if ever, experiences a low intensity fire; we neither observed nor sampled any stand on the Alkali Creek burn that would have been rated low intensity (with limited mortality of the juniper or partial consumption of their crowns).

PONDEROSA PINE WOODLANDS

In high intensity burns where ponderosa pine is dominant, all the pines are killed and their smaller branches consumed; in severe cases the bark was mostly burned off or severely charred and subsequently shed. These stands burned so hot that Rocky Mountain juniper's former presence was revealed by limbless boles or dished-out stumps, in some cases reduced to ground height. Although the tree height and density is highly variable we believe these stands were mature- to old-growth in their structure/age. There may be the anomalous surviving tree or cluster in the midst of what appears total incineration. The shrub component is extirpated as well and there is no indication of its re-establishment four years post-

fire, except in the cases of root-crown sprouters such as black greasewood (*Sarcobatus vermiculatus*), common snowberry (*Symphoricarpos albus*), and skunkbush sumac (*Rhus trilobata*).

Virtually all the herbaceous component survived the hot fires by resprouting from perennating tissues following the fire, although with highly altered relative importance among the constituent species. We consider the most consistent and salient result to be dramatic increases in Japanese brome and lesser responses for species generally considered increasers with disturbance such as (in approximate order of decreasing importance) prickly lettuce, yellow sweetclover, pepperweeds (*Lepidium* spp., especially clasping pepperweed (*Lepidium perfoliatum*)), tiny trumpet (*Collomia linearis*), tall tumble mustard (*Sisymbrium altissimum*), field filago (*Filago arvensis*), western tansy mustard (*Descurainia pinnata*), flixweed tansy mustard (*Descurainia sophia*), yellow salsify (*Tragopogon dubius*), thyme-leaved spurge (*Euphorbia serpyllifolia*) and Canadian horseweed (*Conyza canadensis*). Canada thistle (*Cirsium arvense*) and bull thistle (*Cirsium vulgare*) were the only noxious weeds found; Canada thistle occurs in dense patches and exhibits as much as 15% canopy cover.

Among stands there is a broad range of responses for the herbaceous component subjected to hot fires. This variability is probably due to pre-existing composition, but may in part, be attributable to differential fire intensity among stands. There appears to be an inverse relationship between the response of Japanese brome and the native grasses, particularly sun sedge and thickspike wheatgrass. Japanese brome cover can range as high as 70-80%. When high, the other grasses are generally reduced in cover to less than 10%. In more open, possibly younger stands, where the pre-fire graminoid component may have been appreciable (especially thickspike wheatgrass in openings) the thickspike wheatgrass apparently expands from what were openings in the canopy to attain canopy cover approaching 70%. The response of sun sedge is highly variable, from near extirpation to coverage's in the range of pre-burn values (20-30%). It can be eliminated on an area the size of a plot (0.1 acre), though it was not extirpated from a stand, only reduced to scattered populations in trace amounts. Of the native graminoids, bluebunch wheatgrass seems least impacted by the fire; in fact, four years post-burn it still manifests a fertilizer effect with more robust tussocks than those of unburned areas and its cover values (absent to 12%) match the range reported from unburned stands.

Native perennial forbs are present in pre-burn stands in mostly trace amounts and much the same is seen in post-fire conditions. Only three species, white prairie aster (*Aster falcatus*), prairie smoke (*Geum triflorum*) and harebell (*Campanula rotundifolia*), showed any evidence of being negatively impacted or eliminated on a local basis. Prairie thermopsis (*Thermopsis rhombifolia*) is the only native forb that gave an indication of being favored by fire.

Fires that burned with less severity were indicated by a few scattered survivors, standing dead with intact crowns and a number of trees that survived the initial fires but succumbed at a later date (as indicated by the presence of browned needles). These stands exhibited the same sort of response pattern with regard to Japanese brome and sun sedge as seen in the hot burns; high cover of Japanese brome is associated with low sun sedge cover and vice versa. A small portion of one stand with unburned trees provided insight into burn response by having a high cover (>30%) of sun sedge and robust patches of thickspike wheatgrass well distributed; the burned counterpart within the same stand had even more abundant thickspike wheatgrass (and Japanese brome) and less than 3% sun sedge.

Low intensity burns kill less than 10% of the mature ponderosa pine stems (>5 inches dbh), but nearly 100% of the seedlings and saplings (up to 5 inches dbh). Even a few Rocky Mountain juniper trees survive, but most are killed, though their branches are not wholly consumed as in hotter fires. The shrub component is consistently represented by low coverage (<3%) of common snowberry and Woods rose (*Rosa woodsii*). The graminoid composition is little changed with respect to unburned conditions; sun sedge retains its dominance with a cover from 20 to 40% with bluebunch wheatgrass the next most

abundant with cover in the range of 3 to 5%. Compared to their response on hotter burns, thickspike wheatgrass and Japanese brome are non-responders with canopy cover not exceeding 2%. Forbs such as white prairie aster (*Aster falcatus*), prairie smoke (*Geum triflorum*), Nuttall's violet (*Viola nuttallii*), and harebell (*Campanula rotundifolia*), species eliminated on hotter fires, retain a presence under these conditions. Roundleaved thermopsis is the most abundant native forb that is not traditionally considered an increaser. The cast of increaser forbs e.g. prickly lettuce (*Lactuca serriola*), tansy mustard (*Descurainia* spp.), yellow sweet clover (*Melilotus officinalis*), yellow salsify (*Tragopogon dubius*) are present in reduced numbers on any one plot; they were never found to have more than 1% canopy cover, which is a distinct contrast to their hot fire response. The only noxious weed found is Canada thistle (*Cirsium arvense*) in trace amounts.

SHRUBLANDS

We hypothesize that nearly the whole study area, not potentially woodland-dominated, have the potential to support shrublands with at least 10% canopy cover. A few exceptions occur in the graminoid-dominated riparian zone of draws, portions of floodplains and thin-soil sites overlying Hell Creek sandstone/shale outcrops. We further speculate that the Alkali Creek Fire study area is currently graminoid-dominated due to past fires. By far the greater portion of this shrub potential would be realized by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). As circumstantial evidence we cite the fact that both live and dead Wyoming big sagebrush plants were found in virtually all upslope landscape positions in stands that are currently dominated by wheatgrass. We found no obvious soil differences between sites supporting Wyoming big sagebrush and those supporting rhizomatous wheatgrass-dominated grassland. The general response of shrub-dominated study area landscapes following fire is the temporary elimination (non-sprouters) or reduction (sprouters) of the shrub component and a flush in the graminoid cover (increased tiller number in rhizomatous grasses) and stature.

Areas lacking the potential to support Wyoming big sagebrush appear to be developed on sites with sodic or alkali soils as indicated by the presence of black greasewood (*Sarcobatus vermiculatus*). This species is reputed to readily resprout from the stem base/root crown following fire (Daubenmire 1970) and this response was observed at most burned sites, though we noted at least 50% mortality in some stands. Stands with high mortality were post-fire dominated by a lush cover of thickspike wheatgrass (*Elymus lanceolatus*) possibly indicative of copious fuels existing prior to the burn as well.

Recent analyses of treatment programs applied to Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and in southwestern Montana it was found that at least 30 years are required for burned plots to exhibit cover not different from that of control plots (Wambolt et al. 2001). In some burned plots there was no re-establishment of Wyoming big sagebrush 6 years after burning, in spite of the availability of a seeds from untreated plots immediately adjacent. Eighteen years following burning, the cover of Wyoming big sagebrush was still only 1.8% whereas the control was 15.7% (Wambolt and Payne 1986). The most unsettling finding concerned a mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) site that in a 6-year monitoring period conducted 10 years after the burn, no establishment of sagebrush on the burn site was found, whereas the control experienced a doubling of sagebrush cover (Wambolt et al. 2001). The doubling of cover on the control plots indicated that favorable environmental conditions existed for sagebrush growth and recruitment during the monitoring period.

A further consideration in burning sagebrush in landscapes such as the CMR, where fire can consume continuous and extensive acreage, is the finding that sagebrush adjacent to treated areas is of no practical importance as a seed source for re-establishment (Johnson and Payne 1968). In essence, sagebrush elimination over large areas will require considerably greater and unknown periods of time to re-establish than the timelines (>30 years) documented from control studies. Wambolt et al. (2001) notes the irony in

manager's expressions of wanting to increase productivity of big sagebrush taxa through prescribed burning, citing the values of a mature sagebrush community as their justification. This goal implies that sagebrush will recover rapidly following burning, which simply appears not to be the case.

GRASSLANDS

Growth habit and season of burn are the principle variables regulating the response of grasses to fire (Volland and Bell 1981). Rhizomatous species are frequently favored by fire, as fire probably stimulates the initiation of new shoots at primordial regions of the root system (Gartner et al. 1978). Most of the study area grassland is conspicuously dominated by thickspike wheatgrass (*Elymus lanceolatus*), a species well-known to be fire-tolerant. Thickspike wheatgrass increases in abundance following fire (Wright and Bailey 1982); following planned sagebrush-grassland fires, thickspike wheatgrass plants soon spread and dominate the ground cover (Wasser 1982). Post-burn recovery time is rapid (2 to 5 years) in the sagebrush and pinyon-juniper zones of the Intermountain region (Young 1983). In some Intermountain sagebrush communities bunchgrass production on burned plots remains above that on controls for about 30 years (Harniss and Murray 1973); it is unknown at this time if a similar response is registered for thickspike or other rhizomatous wheatgrasses. Thickspike wheatgrass also recovers more rapidly on ungrazed pastures than on grazed experimental plots (Clarke et al. 1943, Mueggler and Blaisdell 1958).

Several observations made in the study area are applicable here. We noted that grasslands in the vicinity of, and on the western approach to burned woodland stands, and hence occurring on positions with a high probability of being in the fire's path exhibited 1) very high cover of thickspike wheatgrass, 2) robust specimens of bluebunch wheatgrass, and 3) Japanese brome cover many times greater than for unburned portions of these stands. This condition contrasts with thickspike wheatgrass-dominated patches associated with the eastern peripheries of unburned stands that exhibit less robust tillers and much less graminoid canopy cover and only trace amounts of Japanese brome, thus giving no indication of having been burned.

A similar increase in thickspike wheatgrass was documented (burned vs. unburned plots quantitatively measured) in similar terrain and for analogous communities in the Bull Mountains following a massive fire in 1984 (Western Technology and Engineering 1991). The increases of thickspike wheatgrass were so great in the Bull Mountains that investigators declined to use it as an indicator or nominal species fearing it would confuse the distinction as to what was a potential vegetation type and what was an expression of post-fire succession. A minor response distinction between the Bull Mountain grasslands (actually across most vegetation types held in common by the two areas) and those of the Alkali Creek study area is that, in addition to Japanese brome, cheatgrass (*Bromus tectorum*) was also present and increased markedly capturing some of the space and resources that was Japanese brome's alone to utilize in the Alkali Creek landscape.

WOODLAND AGE AND STRUCTURE

Maintaining ecosystems within their range of natural variability is an emerging objective of ecosystem management that entails attention to pre-Euro-American landscape-scale processes and their resultant landscape structures (e.g. old-growth forest distribution). The nature of our data (primarily tree cover by structural classes) does not lend itself to a concrete analysis of stand structure such as would an inventory of stem counts by narrow, discrete diameter classes. However, we can make some general comments regarding structure, in particular addressing the old-growth nature of study area stands and the threats posed to them by catastrophic fire. A universal definition of old-growth is not useful, perhaps even

misleading, due to the diversity of ecological attributes associated with different forest types (Hunter 1989). Two approaches to defining old-growth have evolved, structure-based and process-based. The structural approach can be readily applied in the field to identify old-growth forest stands, if structural parameters are first defined by geographic region. Some of the structural attributes of old-growth include: numerous and widely spaced large diameter trees; more numerous crown and bole deformities (than in younger stands); a reverse J-shape diameter distribution curve; standing dead trees; increased coarse woody debris (fallen logs and branches). Stand disturbance history and age are the primary measures employed in defining process approaches to old-growth.

Applying the structural approach, Green et al. (1992) cite a minimum of 4 trees / acre > 17 inches to meet the east-side Montana criterion for old-growth ponderosa pine stands and Mehl (1992) relaxes this criterion by one inch (>16 inches) for the Front Range (Colorado) and Black Hills. In the Alkali Creek area, ponderosa pine stands judged to be old-growth were probably in excess of 50% in the pre-burn landscape and in excess of 30% in the post burn landscape. These percentages were arrived at by judging the canopy cover of the 9 to 18 inch and > 18 inches diameter classes, which was generally from 10 to 30 % (generally 2-10 trees / 0.1 acre plot). Comparing study area stand ages with the 180-yr and 160-yr minimums for old-growth cited by Green et al. (1992) and Mehl (1992) we arrive at a figure similar to that based on diameter distribution of about 30% to 40% old growth stands within the study area. Of those study area stands not classed as old-growth, most would qualify as mature and fewer than approximately 10% as seedling-sapling or stand initiation phase of development.

Other structural features, presence of a reverse J-shape diameter distribution, quantity of coarse woody debris, and bole and crown deformities can only be tangentially addressed. The amount of coarse woody debris was approached through the “wood” category of the “ground cover” field. None of the unburned stands had more than 3% woody debris; mostly just trace amounts were present. Three percent woody cover could be contributed by just one sizable downed tree on a 1/10-acre plot. This apparent lack of woody debris is not surprising in a vegetation type where there is virtually no self-thinning of the canopy, and underburning, though ostensibly much reduced since settlement times, is still a factor in consuming such fuels.

Bole and crown deformities were not explicitly recorded, however, in selecting trees to core many tree crowns and boles were appraised and rejected as unsound and poor candidates for obtaining a readable core. A high rejection rate testifies to the general deformity of the older trees, usually having flat or broken tops. Flattened tops are an expression of older trees that attain maximum height early in life; they cannot achieve more than 48-50 feet in these woodlands and can't maintain apical dominance due to a host of factors. A broad, continuous distribution of tree cover across diameter classes was the most frequently encountered structure. This is circumstantial evidence that past fires were not stand-replacing and/or that reproduction is episodic, thus allowing stands to develop this uneven-aged structure. Several of the burned stands appeared to have had canopies with a narrow height range and boles with a restricted diameter distribution leading to speculation about even-aged structure. Even-aged structure, or an approximation, could be generated in this landscape by stand-replacing fire accompanied by a burst in seedling recruitment. This type of structure would certainly be atypical given that ponderosa pine reproduction within this semi-arid environment is primarily episodic with limited seedling recruitment and that, at least prior to settlement times, under-burns (ground fire) would probably have created canopy gaps to be filled by subsequent reproduction.

In at least two plots where the oldest trees were over 140 years old (older than the presumed advent of Euro-Americans in this landscape) no visible fire scars were observed; this is not to say the other trees in the stand were not scarred, or rule out the possibility of “hidden” fire scars. Unfortunately notes regarding fire scars were incomplete so that no statistics could be expressed on this feature. In Montana's Bull Mountains Morgan et al. (2001) recorded 10 ponderosa pines with hidden fire scars (revealed only by

coring trees) out of a 200+ tree sample. The Bull Mountains old-growth study in the drier ponderosa pine / bluebunch wheatgrass plant association (Morgan et al. 2001) found between 14 and 43% of the ponderosa pine within a given stand to be fire scarred and that across all their sampling sites trees having a diameter at breast height (dbh) of less than 12 inches had no fire scars whatever. Within their study area the 12-inch dbh limit corresponds to an age of approximately 140 years and the influx of Euro-Americans and fire suppression (though obviously fire suppression is not 100% effective). Our results contrast somewhat with those of Morgan et al. (2001) as several of our younger stands (<120 years based on basal age) had evidence of multiple fire scars. In general we found that a scarring diameter limit of approximately 12 inches applies in our study area as well.

GAP COVER TYPES

A significant proportion of the Alkali Creek study area topography approaches that of a badlands landscape, being highly dissected and downcut. Only the fact that it is nearly continuously vegetated, with the minor exception of some highly eroded knolls, ridges and bare-faced sandstone escarpments, argues for calling it merely a convoluted breaks-type of environment. Semi-arid environments exhibiting such a diversity of slope facets and degrees of slope signal the probable existence of an equally complex vegetation cover type pattern. The complexity of vegetation cover types as revealed in the GAP classification is presented in Figure 4. Visual inspection of this map reveals some types, such as Salt Desert Shrub, CRP, Non-Native Grass, that obviously are not present within the study area (established by visual reconnaissance). However, the only objective way to test map accuracy is to compare accurately geo-referenced ground truth plots with the identified cover type for the cell that corresponds to the geo-referenced point. Our vegetation plots were chosen for how well they represented a particular plant association or successional stage or fire response, and not whether they were extensive and thus more likely to fall into a particular vegetation cover type. They were also not placed in the center of a stand (or polygon of a particular cover type). In assessing how well GAP cover type mapping performed in this landscape we thought it appropriate to select for analysis those sampling points that are representative of a relatively extensive vegetation type, at least 200 m on a side, to minimize edge effects.

Table 4. GAP cover vegetation types found in the Alkali Creek Fire Study Area. These types are identified from 30 m pixels corresponding to ground truth point locations (types having same number following colon have been combined for analysis, see text).

GAP Cover Types (Numerical Identifier)	Identified by Ground Truth	Identified via Remote Sensing
Non Native Grasslands (3111) : 1		X
Conservation Reserve Program Lands (3115): 1		X
Low Cover Grasslands (3140): 2		X
Low-Moderate Cover Grasslands (3150): 2	X	X
Moderate / High Cover Grasslands (3170): 2	X	
<i>Artemisia cana</i> Shrubland (3309): 3		X
<i>Sarcobatus vermiculatus</i> Shrubland (3311): 3		X
<i>Artemisia tridentata</i> Steppe (3350): 4		X
Xeric Mixed Shrubs (3360)		X
Xeric Shrub Grasslands (3520): 4	X	X
Tree-Grassland Associations (3530): 5		X
Low Density Xeric Forest (4000): 5	X	
<i>Pinus ponderosa</i> Forest (4206)	X	X
<i>Juniperus scopulorum</i> Woodlands (4214)	X	X
Mixed Xeric Forest (4290)		X

GAP Cover Types (Numerical Identifier)	Identified by Ground Truth	Identified via Remote Sensing
Graminoid and Forb Riparian (6200)	X	
Badlands (7600): 6	X	X
Mixed Shrub Badlands (7603): 6	X	X
Missouri Breaks (7604): 6		X

A further modification was the grouping of some vegetation types in consideration of the approximate five years lapse since the remote sensing scene was acquired and classified and the vegetation changes that could have occurred in response to short-term climate and land use changes (removal or lowering of stocking rate of domestic ungulates from some ranges). This was the reasoning behind grouping the low, moderate, and high production grasslands (see Table 4). Some categories were grouped on the basis of their very similar or overlapping vegetation descriptions; there was no way a plot could be assigned unequivocally to one or another of the choices with the information provided; for example, Tree-Grassland (3530) could not be consistently distinguished from Low Density Xeric Forest.

Table 5, a matrix indicating the match between the cover type call from ground truth and that from the classified scene, cannot be statistically analyzed due to low numbers for each cell; however, some qualitative trends can be noted. In general GAP does a credible job (63% correct) of predicting grassland types (#s 3140, 3150, 3170) when presented with open terrain and performs even better (89%) when making the call to the correct dominant lifeform (grasses with an equal or lesser amount of shrub).

The category containing Xeric Shrub Grassland (3520) and *Artemisia tridentata* Steppe (3350) is poorly predicted (33%) in rolling terrain but, when considered in the context of predicting a shrub canopy of sagebrush with a variable amount of grass then it is relatively adept (82%). This category might have expressed higher accuracy had not fire burned the landscape. It is entirely possible clues to the existence of a sagebrush stand were missed during inventory and sites were mistakenly ground-truthed as grasslands, when in fact they had a sage component at the time of scene classification.

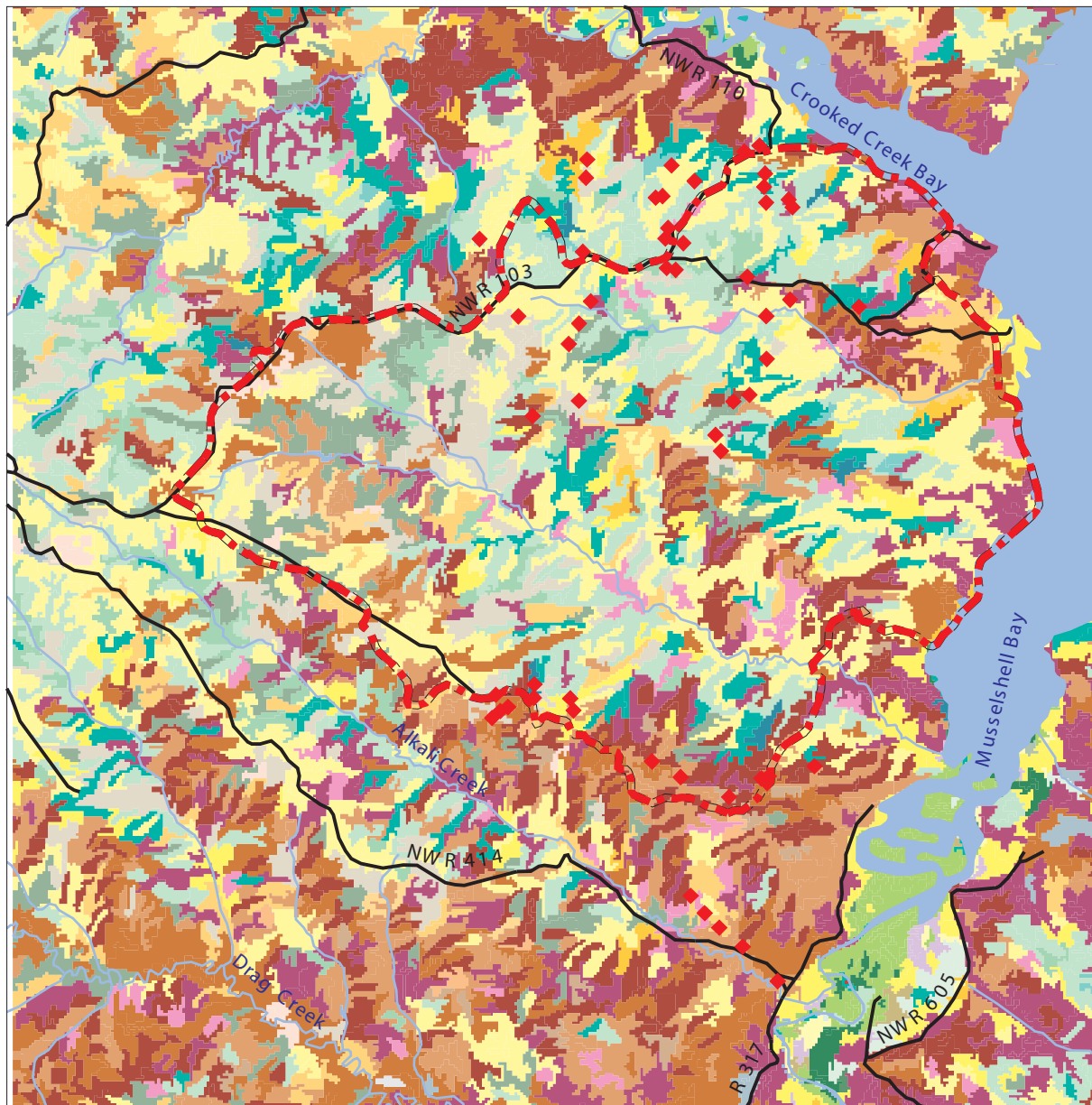
Where tree density is low, in the range of that expressed by a savanna (Low Density Xeric Forest, 4000 and Tree-Grassland Associations, 3530) there were no sampled occurrences in extensive polygons. Only one plot (25%) was correctly placed when the category was taken as a lifeform type (with trees constituting a significant cover, > 10%).

Where it occurred in relatively extensive stands the Ponderosa Pine type (4206) was identified about 64% of the time. It should be noted that these plots, while associated with a particular stand, were in fact taken from the periphery of the stand so this accuracy figure could be expected to improve if ecotonal situations were avoided. If just the call to a correct dominant lifeform (with significant tree cover) was expected, then about 80% of the calls were correct.

Rocky Mountain juniper occurring as the canopy dominant is a definite vegetation condition (#4214) within the study area but, it was sampled only once as an extensive type. This lone plot was not assigned by GAP to this specific woodland type, however this plot was correctly identified as having a prominent tree canopy (assigned to 4290, Mixed Xeric Forest).

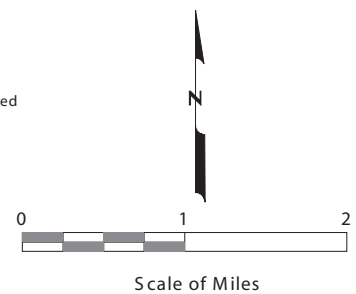
Three plots were classified from ground truth as Graminoid & Forb Riparian (6200) but none were correctly identified to this category by GAP. This is somewhat to be expected given that all the occurrences are linear, from narrow drainages (<30 m) and expected to be grouped with immediately upslope cover types, which were grasslands. However, GAP correctly called the adjacent vegetation type as being grassland only once.

FIGURE 4. GAP Vegetation Covertypes for the Alkali Creek Fire Study Area



GAP Vegetation Covertypes

Non-Native Grass	Salt Desert Shrub	Mixed Broadleaf Forest	Willow Dominated Riparian
CRP Lands	Greasewood	Ponderosa Pine	Other Shrub Dominated Riparian
Very Low Cover Grasslands	Big Sage Steppe	Douglas fir	Badlands
Low Cover Grasslands	Greasewood Big Sagebrush	Rocky Mountain Juniper	Mixed Shrub Grass Badlands
Low/Moderate Cover Grasslands	Juniper Sage Grass	Mixed Xeric Forest	Missouri Breaks
Moderate/High Cover Grasslands	Mesic Shrub Grassland	Water	Mixed Barren Land
Mixed Mesic Shrubs	Xeric Shrub Grass	Broadleaf Dominated Riparian	96 Fire Perimeter
Xeric Shrubs	Tree Grassland Associations	Graminoid and Forb Riparian	
Silver Sage	Aspen	Shrub Dominated Riparian	



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Table 5. GAP ground truth matrix showing correspondence between cover types assigned from ground truth and that assigned from the classified Landsat Scene (refer to Table 4 for names corresponding to Vegetation Cover Type numbers)

		Vegetation Cover Types Assigned by GAP										Percent Correct Identification
		3111 & 3115	3140 & 3150 & 3170	3309 & 3311	3350 & 3520	3360	3530 & 4000	4206	4214	4290	7600 & 7603 & 7604	
Vegetation Cover Type Assigned by Ground Truth	3140 & 3150 & 3170		5 / 0		1 / 0	2 / 0		0 / 1				63 / 55 / 89
	3350 & 3520		2 / 2	1 / 1	1 / 0						2 / 2	33 / 09 / 82
	3530 & 4000	0 / 1	1 / 1			0 / 1		0 / 1				0 / 0 / 25
	4206	0 / 1	1 / 1	1 / 2			0 / 1	7 / 1	1 / 0	1 / 1	0 / 3	63 / 33 / 80
	4214			0 / 1						1 / 0		0 / 0 / 50
	6200		1 / 0					0 / 1		0 / 1		0 / 0 / 33
	7600 & 7603 & 7604				0 / 2						2 / 1	100 / 40 / 100

In cells with dual entries the number left of the slash represents the number of times that ground truth indicated a particular vegetation type was present in an extensive polygon. The number to the right represents the same, except rather than extensive, the vegetation type is a small patch stand or highly faceted landscape. A wished-for outcome would be for all the numbers (both to right or left of slash) to occur along the diagonal. It should be noted this is not a symmetrical matrix because some of the GAP predicted categories simply were not substantiated by ground truth. The right-most column of Table 5 labeled “Percent Correct Identification” has three slash-mark separated figures. The left-most figure in each cell indicates the percent correct assignments of plots to vegetation cover type for what were judged to be polygons of extensive areas of a particular vegetation type based on field evaluation. The figure centered between slash marks indicates the percent of plots correctly assigned based on **all** plots identified as being assigned to a particular vegetation type; this percentage takes no account of whether the plot was sampled in highly dissected terrain where vegetation type could be expected to reflect a fine-grained vegetation matrix. The right-most number in this column indicates the percent of plots correctly assigned, based on the correct dominant lifeform call within a particular table row. For example, in row one, types 3140, 3150, 3170 are grasslands, types 3350, 3520 and 3360 are dominated by grasses with an equal or lesser amount of shrubs and only type 4206 (*Ponderosa Pine Forest*) has a distinctly different lifeform (tree) as a dominant. Therefore 8 of 9 assignments, 89%, of assignments are correctly attributed to the cells with grasslands/shrublands dominant.

The amalgam of badlands types (#s 7600, 7603, 7604), if they occurred as an extensive polygon (only two plots in dataset), was correctly placed by GAP. If a more general response is evaluated where GAP picks up on the nature of shrub dominance within these plots, then all plots were correctly predicted regardless of landscape setting or polygon size.

It should be noted the middle value of the slash delimited values was always lower than the first value, which is to say that smaller polygons, broken terrain or more heterogeneous landscapes are, as expected, factors decreasing the accuracy of the classification.

Overall about 54% of the relatively extensive polygons were correctly predicted to cover type group. Prediction of the dominant lifeform is correct in about 79% of the cases (based on extensive polygons). These study area figure are reasonable given that the overall GAP class-specific accuracy for the state is given as 61% and at the “acceptable” level as 89% (their “acceptable” level corresponding to our “dominant lifeform” call).

CONCLUSIONS

We found a relative lack of Wyoming big sagebrush-dominated acreage compared to its extent in surrounding landscapes and especially notable was its absence from expansive, gently rolling terrain. This is an extremely important habitat component for sage grouse (*Centrocercus urophasianus*), a species in decline ostensibly owing in part to loss of habitat. Given the recently documented slow rates at which *Artemisia tridentata* re-establishes in burned communities and assuming only natural processes are allowed to revegetate burned areas it could be scores of fire-free years before this species reoccupies its presumed potential habitat.

A more perplexing observation is that Wyoming big sagebrush communities in the Alkali Creek landscape have apparently been relegated to a few protected positions, usually ridges and mesa tops, occurring as relatively small stands or patches. This contrasts with areas in northern Petroleum County, where for the most part Wyoming big sagebrush occurs in large patches many hundreds of acres in extent or as a matrix type where the large (and small) patches are not separated by barriers of any extent. One can hypothesize several explanations, none necessarily correct in part or in whole. One explanation may be that a higher fire frequency, or at least more ignitions, occur in the immediate environs of the ponderosa pine stands on the southern outskirts of Missouri Breaks as opposed to ignition frequencies within landscapes further to the south (or north). Alternatively it may be, that following settlement and somewhat effective fire suppression, that Wyoming big sagebrush increased over the whole northern Petroleum County landscape. What is seen in the study area vicinity is the result of wildfires allowed to run on USFWS holdings while on private and BLM holdings fires (wildfire or other) have been extinguished.

Though we may ponder the above-posed question without satisfaction, a more important and encompassing consideration is what was the pre-settlement status (extent) of Wyoming big sagebrush in this greater landscape and how critical to the conservation of this resource might be the CMR. Big sagebrush (*Artemisia tridentata* without regard to subspecies) is critical habitat for sage grouse (*Centrocercus urophasianus*) and a major winter-early spring dietary component for elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*). In the Gardiner Basin north of Yellowstone National Park in Wyoming, big sagebrush studies of post-fire recovery under continuous browsing indicate that 19 years after the fire only a 1% recovery compared to adjacent unburned control stands. This difference is all the more significant in light of the fact that the unburned stands were already in decline from historically intensive browsing (Mehus 1995). The message here is that should the refuge’s big sagebrush resource be reduced by fire over extensive acreage, then the remnant populations will come under browsing stress,

which can ultimately result in their demise as well, as graphically demonstrated in the Northern Yellowstone Winter Range (Wambolt 1998).

Though all the above noted noxious weeds have- the potential to become serious pests, we speculate the most immediate threat to study area rangeland values and watershed protection is the annual alien grass Japanese brome. It is noteworthy that both Japanese brome and cheatgrass (*Bromus tectorum*) are considered noxious weeds by the adjacent province of Saskatchewan (Alberta and Manitoba list *Bromus tectorum* as noxious as well). Judging by Japanese bromes' proliferation and continuing high cover on severe- to moderate-burns in woodlands, shrublands and grasslands, and in response to the Alkali Creek Fire, this species will continue to increase at the expense of native forbs and graminoides.

Our interpretation of the successional response of Japanese brome in CMR woodlands is somewhat discordant with what has been found further east in the northern Great Plains for grassland environments. Researchers in South Dakota (Whisenant and Uresk 1990), Texas (Whisenant et al. 1984), and Montana (White and Currie 1983) report at least an initial reduction in Japanese brome following fire but within one or two years these burned areas are "repopulated". Whisenant and Uresk (1990) also noted that when burning is followed by below average precipitation years, drastic Japanese brome population reductions result. Such a response has probably not been the case for Japanese brome study area populations, especially in burned woodland stands. There is every indication that, at least in woodlands, pre-burn Japanese brome populations had been minimal (<1% cover) and that an exponential increase has occurred in the succeeding four years. This ostensible increase in brome has come about despite the years succeeding the Alkali Creek Fire having been relatively dry, which should have depressed the Japanese brome populations. It is unlikely that an abundance of Japanese brome existed in the seed bank prior to the fire, given its one to two year seed longevity and that it was not abundant outside the woodland stands. Therefore, this alien annual, between the burn year of 1996 and inventory of 2000, had to have increased remarkably, whether incrementally via consecutive successful seed-producing years on the site or by some other mechanism is moot.

The appreciable component of Japanese brome in CMR shrubland and grassland stands is more problematical. Kirsch and Kruse (1972) have proposed a general model that maintains following the settling of the northern Great Plains the reduced fire frequencies and the resulting litter accretion promoted the establishment and spread of Japanese brome. Subsequent studies have shown that Japanese brome germination is largely dependent on litter accumulation (provision of favorable microsites); as litter accumulates then an increase in Japanese brome will be seen (Whisenant and Uresk 1990). Japanese brome growth is also inversely correlated with western wheatgrass standing crop and tiller density (Whisenant and Uresk 1990). Corollary to this is that livestock grazing and fire decrease litter accumulations and will reduce Japanese brome as well, however, differential grazing of the more palatable western (or thickspike) wheatgrass should favor Japanese brome. The Kirsch and Kruse (1972) paper is conjectural and we have misgivings about their contention that the reduction of fire frequency resulted in litter accretion and increases in annual bromes in light of the fact that immense numbers of livestock were put onto the western range in the late 1800's. It is difficult to envision the pervasive overgrazing that occurred on the northern range (Donahue 1999) could have resulted in increased litter levels and thus more favorable microenvironments for Japanese brome. The findings of Whisenant and Uresk (1990) and the other above-cited authors, though based on empirical evidence, were nevertheless obtained from a slightly different grassland type, under a higher precipitation regime and under spring burning conditions. The Alkali Creek Fire, having occurred in late summer (as most naturally occurring fires do in this climatic regime) after the Japanese brome had shed seed, may have set in motion a different successional course. We can only speculate that shed brome seed survived the fire to initiate the following years' stand and faced reduced competition from the burned-back rhizomatous wheatgrasses. If the Japanese brome truly did increase on the burned area grasslands then the above explanation has still

not accounted for why the loss of litter via the fire did not in fact serve as a countervailing measure to depress the brome population.

If the consequences of spring burning hold on the CMR grassland/shrublands, then managers will have to strike a delicate balance in the landscape, maintaining healthy native grasslands through controlled spring burns (to check the Japanese brome population) and promoting Wyoming big sagebrush through fire abatement in other areas. Because fire cannot be run through Wyoming big sagebrush stands without the loss of the sagebrush, brome populations would be predicted to burgeon in these communities; perhaps the introduction of native ungulates to this landscape would be a solution to the conundrum posed by the accumulation of litter.

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APPENDIX A. PLANT COMMUNITY DESCRIPTION

Juniperus scopulorum / *Elymus lanceolatus* Woodland Rocky Mountain Juniper / Thickspike Wheatgrass Woodland

ELEMENT CONCEPT

Environment: This small patch community occurs from mid to upper slopes of gentle to steep, north- to east-facing slopes, often tucked into protected slope facets. Substrates are shales and siltstones, with and without a veneer of glacial drift; they weather to primarily clay and silt loams. In general, the surface is more than 70% litter and basal vegetation however, at least two sites had more than 70% exposed soil (and gravel) and all sites evidenced some degree of erosion, including sheet and rill.

Vegetation: This description is based on both post-burn and pre-burn plots. Tree and shrub cover is partly reconstructed from post-burn skeletons and other evidence. The canopy cover of the diagnostic tree species, *Juniperus scopulorum*, ranges from about 10-15% to around 50%; though not multiply branched at the base, its form is distinctly shrub like with maximum heights being in the 8 to 12 feet range. *Sarcobatus vermiculatus* is the shrub with the greatest constancy and cover, as high as 5 %. The undergrowth description is based largely on post-burn plots; we assume the same species to be present in preburn conditions but, in reduced coverage and altered relative amounts. *Elymus lanceolatus* is both a dominant and diagnostic undergrowth species with cover ranging upward from 20%, especially in post-burn conditions. The other diagnostic species, *Carex inops* ssp. *heliophila*, exhibits a highly variable response from being absent to 30% or more cover. Other highly constant graminoids include *Nassella viridula*, *Pseudoroegneria spicata* and the invasive *Bromus japonicus*. There were no forbs identified with either high constancy or more than trace amounts of cover (excepting some increaser species).

Dynamics: This community differs from the other communities described in this report; it is our speculation that this community represents, not a potential natural community (climax stage), but rather a post-disturbance seral expression of the *Pinus ponderosa* – *Juniperus scopulorum* / *Carex inops* ssp. *heliophila* association. We are encouraged in this speculation because the *Juniperus scopulorum* / *Elymus lanceolatus* community occurs on the same landforms and positions as do *Pinus ponderosa* – *Juniperus scopulorum* / *Carex inops* ssp. *heliophila* and its post-fire seral permutations. In addition, the undergrowth composition is very similar to that of the *Pinus ponderosa*-dominated sites; these are the only *Juniper*-dominated sites where *Carex inops* ssp. *heliophila* is well represented. *Elymus lanceolatus* does exhibit much higher cover on these sites than within the *Pinus ponderosa*-dominated sites ostensibly owing to the more open canopy and greater light penetration. *Elymus lanceolatus* cover notably increases in response to canopy gaps in mature *Pinus ponderosa* stands (and may be absent in the denser stands). It is also on these sites where *Lactuca* spp. invade post-fire and seem to persist until the canopy becomes relatively closed. How to account for the fact that *Pinus ponderosa*, at least as could be determined from burned remains, is not represented on these sites? We speculate that succession is a very slow process with tree seedling recruitment being one of the rate-limiting processes. As noted elsewhere in this report, in the course of inventory (observations not restricted to just plot locations) only two *Pinus ponderosa* seedlings, thought to be established since the Alkali Creek Fire, were found. Regarding *Juniperus scopulorum* we found no small seedlings and the smallest specimen was about a foot tall and 16 years old. Most *Juniperus scopulorum* stands appear to be relatively even-aged. Reproduction of these two tree species in this semi-arid environment is apparently a highly episodic process.

In several stands all clumps of *Sarcobatus vermiculatus* (that could be identified as such) sprouted post-fire. Whereas in other stands, those in which some areas possibly experienced a hotter fire, mortality of stem clusters approached 50%. Stem-remains evidence that *Artemisia tridentata* ssp. *wyomingensis* had been a stand component was not found

Similar Associations: *Juniperus scopulorum* / *Pseudoroegneria spicata* Woodland (CEGL000748)

GRank & Reasons: G?

Comments: This community is a provisional, pending further inventory and classification. The MTNHP has described this community from four plots (unburned and post-burn reconstruction) in the Alkali Creek study area. This is far from an ideal solution but in light of the fact that most of the study area representations of the type appeared to have been burned and stands in the unburned terrain were not readily located, there appeared to be little recourse.

ELEMENT DISTRIBUTION

Range: This association is currently known only from the Alkali Creek study area, though a similar condition has been noted in the vicinity of the Two Calf-Douglas-fir Research Natural Area.

Nations: US

States / Provinces: MT: S?

ELEMENT SOURCES

Author(s): Cooper, S. V., C. Jean MTNHP **Confidence:** 3 **Identifier:** CEGLMTHP72

References:

***Pinus ponderosa* – *Juniperus scopulorum* / *Carex inops* ssp. *heliophila* Woodland**
Ponderosa Pine – Rocky Mountain Juniper / Sun Sedge Woodland

ELEMENT CONCEPT

Environment: This matrix type association occurs on moderate to steep slopes, primarily with northerly to easterly exposures. Though designated a matrix type, individual stands are usually small, less than 5 acres; matrix is the appropriate term because in the context of this landscape the occurrences are always separated by less than 0.5 km. It occurs from lowest (2,250 feet) through highest (2,780 feet) study area elevations. The most extensive stands (20 + acres) occur where a ridgeline trends east-west creating a steep north-facing slope or on east-facing slopes above drainage bottoms of north-south trending drainages. Within the study area confines shale (or siltstone) and sandstone constitute the only parent materials, with the former much more extensive. The sandstone is a more weathering-resistant cap rock of study area mini-mesas. On sandstone this association appears restricted to north-facing slopes. The finer textured parent materials weather to clay loams whereas the sandstone produces sandy loams to fine sands. Being that this community often occupies a particular slope facet there are often steep gradients to adjacent vegetation types; those typical of drier sites include *Artemisia tridentata* ssp. *wyomingensis* / *Elymus lanceolatus*, *Pseudoroegneria spicata* – *Pascopyrum smithii* (*Elymus lanceolatus*), and *Elymus lanceolatus* – *Nassella viridula* and toward slope bottoms and toeslopes, or comparably moist positions, a narrow fringe of *Pinus ponderosa* / *Symphoricarpos occidentalis* can be found.

Vegetation: This type is designated a woodland because the combined tree canopy cover of the two diagnostic and dominant tree species, *Pinus ponderosa* and *Juniperus scopulorum*, seldom exceeds 55%, their respective coverages averaging 45% and 12%. The largest *Pinus ponderosa* inventoried slightly exceeded 18 inches in diameter and the height of the tallest trees approaches 50 feet. We noted trees larger in diameter but, crown damage to these very old specimens seems to keep height below 50 feet. The oldest tree cored is 322 years at 1 foot above ground level; we speculate the largest trees are well over 500 years old. The tallest *Juniperus scopulorum* specimens found were in the 10 to 12 foot range. Some have remarked on the possible hybrid (with *Juniperus communis*) nature of *Juniperus scopulorum* on the refuge (Roberts and Sibbersen 1979), which may account for these populations being generally of less than robust form. We found no other tree species but speculate that these sites are not beyond the xeric limits of *Pseudotsuga menziesii* (Douglas-fir). However, the nearest seed source of this species is well removed to the northwest. The undergrowth is highly variable within a given stand (especially the younger stands) but the oldest stands give the impression of greater homogeneity with the diagnostic and rhizomatous graminoid, *Carex inops* ssp. *heliophila*, and *Pseudoroegneria spicata* approaching a uniform distribution (or somewhat uniformly distributed patches). Herbaceous cover is greatest in the canopy gaps. Other graminoids with high constancy are *Koeleria macrantha* (prairie junegrass) and *Elymus lanceolatus* (thickspike wheatgrass); the latter consistently expressing higher coverage in canopy gaps and at the periphery of stands. In late-seral and old-growth stands forbs are reduced to trace amounts; those of highest constancy include *Vicia americana* (American vetch), *Antennaria neglecta* (field pussytoes), *Antennaria microphylla* (rosy pussytoes), *Pedimelum argophyllum* (*Psoralea argophylla*, silver-leaved scurfpea), *Aster falcatus* (white prairie aster), *Thermopsis rhombifolia* (prairie thermopsis), and *Geum triflorum* (prairie smoke or old man's whiskers); only the last three are consistently found in this association and are sporadic at best in contiguous vegetation. Regarding the shrub component, it is depauperate in species number and cover; only *Rhus trilobata* (skunkbush sumac) and *Artemisia cana* (silver sagebrush) were present in more than half the stands. Several stands bore remnants of *Artemisia tridentata* (ssp. *wyomingensis*?) but only a single live specimen was found in a late-seral to old growth stand.

Dynamics: Fire, grazing and drought are the primary agents affecting this association. Regarding grazing, the most palatable components are *Pseudoroegneria spicata* and *Elymus lanceolatus*. However, both these species had healthy populations within the mature study area stands, though *Elymus*

lanceolatus was relegated primarily to canopy gaps. There is a broad spectrum of fire effects that can be expected with this type depending on a plethora of mitigating circumstances such as season of burn (mostly soil moisture), burn weather parameters, fuels situation (graminoid undergrowth component dependent in large part on weather of preceding years) and other site and temporal variables. The Alkali Creek Fire effects can be distilled to three degrees of burn severity, which register as (1) stand-replacing, (2) partially stand-replacing or mixed severity and an (3) underburn (surface fire). Fire is sufficiently patchy within this association that all regimes have been noted within a single stand.

1. With stand-replacing fire and severe ground effects this type becomes forb- to annual exotic grass- to perennial grass-dominated, often all responses can be expected within a few meters of one another, giving rise to a highly variegated undergrowth. Some native graminoids persist even in stand-replacing fires with accompanying high severity effects; we presume these nuclei will eventually serve to recolonize the stand. Some native forbs are extirpated from a given stand and will require animal vectors or other dispersal mechanisms to re-establish.
2. Mixed severity results in a couple of ways (a) a fine-grained pattern of older and younger tree survival due to a mix of understory and stand-replacement fires within a spatially constrained area; variation in topography, fuels, stand structure and most especially highly dissected terrain is conducive to this fire regime (Brown 2000), and (b) many trees are killed by mostly surface fires but many survive; severity of the fire causes selective mortality of the smaller or weaker *Pinus ponderosa* (survival being directly related to bark thickness which in turn is directly related to diameter at breast height and age). Mortality is total for *Juniperus scopulorum*. The undergrowth response is intermediate with the native graminoids and forbs experiencing a decline in cover and with increaser herbs (*Lactuca serriola*, *Descurainia* spp. *Bromus japonicus*) proliferating, but not nearly to the extent seen in high-severity, stand-replacing fire.
3. The underburn regime is nonlethal to the dominant *Pinus ponderosa* size classes, though seedlings and saplings may be killed. With rare exceptions mortality is complete for *Juniperus scopulorum*, though the degree of stem consumption is highly variable and a good secondary indicator of how the patchiness of fire severity. The graminoid component is only slightly negatively impacted, at least as evaluated four years post-fire; in fact, cover for *Elymus lanceolatus* may increase through rhizomatous incursions into previously heavily shaded portions of the stand, where the understory may have been removed. *Pseudoroegneria spicata* response is to increase tussock size and number of seedheads, as in a fertilizer response.

Similar Associations:

Pinus ponderosa / *Juniperus scopulorum* Habitat Type (Roberts and Sibbersen 1979)

Pinus ponderosa / *Carex heliophila* Habitat Type (Hansen and Hoffman 1988)

GRank & Reasons: G3?

This is a newly described plant association; field reconnaissance has shown it to extend beyond the confines of the Alkali Creek study area both to the north and south. Accepting that it is a unique type, its considerable extent just within the study area would merit a G3?.

Comments: We are somewhat puzzled why this association was not described by Roberts and Sibbersen (1979). They described a *Pinus ponderosa* / *Juniperus scopulorum* Habitat Type for public lands immediately outside the Charles M. Russell National Wildlife Refuge that had no *Carex inops* ssp. *heliophila* listed in the accompanying association table; however, the table did show *Pseudoroegneria spicata* as the undergrowth dominant, reflecting a drier environment (than reflected had *Carex inops* been present). Hansen and Hoffman's *Pinus ponderosa* / *Carex heliophila* Habitat Type of southeastern Montana and eastern North and South Dakota has considerably higher *Pinus ponderosa* densities and canopy cover, *Juniperus scopulorum* is not present and the undergrowth shares few ancillary species in common with the association described here.

ELEMENT DISTRIBUTION

Range: This ponderosa pine woodland type currently is described from only the Charles M. Russell National Wildlife Refuge but plot data exists from greater northeastern Montana that confirms its existence and would considerably extend its range in Montana.

Nation: US

States / Provinces: MT: S3?

ELEMENT SOURCES

Authors: Cooper, S. V. and C. Jean, MTNHP **Confidence:** 2 **Identifier:** CEGLMTHP71

References: Hansen and Hoffman 1988, Roberts and Sibbersen 1979

***Pinus ponderosa* / *Pseudoroegneria spicata* Woodland**
Ponderosa pine / Bluebunch Wheatgrass Woodland

ELEMENT CONCEPT

Summary: This ponderosa pine woodland exemplifies one of the driest woodlands found in the northern Rocky Mountains, Intermountain, and extreme northwestern Great Plains of the United States and adjacent portions of Canada. It is usually found on slopes with a high solar insolation load and exhibiting coarse soils, often with a high gravel or rock content. *Pinus ponderosa* is typically the only tree in the overstory, although *Juniperus scopulorum* may be present in the subcanopy. It forms open to moderately closed canopies. There are very few shrubs. The herbaceous layer is dominated by *Pseudoroegneria spicata*. Other species found in this layer are *Carex filifolia*, *Carex inops* ssp. *heliophila*, *Koeleria macrantha*, *Achillea millefolium*, *Balsamorhiza sagittata* and *Hesperostipa comata*.

Environment: This community occurs mostly on steep southerly aspects. It is found on coarse soils derived from sandstone, porcellanate, or limestone (Thilenius et al. 1995). These include sandy alluvium, gravelly or sandy till, and loams with high stone content. Rock and mineral soil are commonly exposed. These are very stressful sites including escarpments, slope shoulders, and moderate to steep south- to southwest-facing slopes, and mesa edges where soil is shallow. It was found predominantly on sandstone or occasionally on fissile shale/siltstone that weathers to sand- or gravel-sized particles and mimics sandstone as it interacts with soil water. The amount of exposed ground (soil and gravel) varies widely (20 to 80%), perhaps more related to the degree of slope than community composition and the production of litter. It is not readily apparent what site parameters separate this community developing on slopes from immediately adjacent communities, either *Pseudoroegneria spicata*-dominated or *Artemisia tridentata* ssp. *wyomingensis* shrub-steppe vegetation that gives no indication of ever supporting *Pinus ponderosa*. Though data is fragmentary it appears that compositional nuances respond to parent material differences (or a related factor).

Vegetation: The tree and herbaceous strata dominate this community. *Pinus ponderosa* is often the only tree in the overstory. The tree coverage can vary from open to moderately closed. In northeastern Wyoming, most of the trees were less than 15 m tall and diameters at breast height less than 60 cm (Thilenius et al. 1995). On three stands in the eastern portion of this type's range, Hansen and Hoffman (1988) found that total cover of the understory strata was 55%. Shrubs made up only 1.3% of this total. The herbaceous stratum is open to moderately dense. *Pseudoroegneria spicata* is the dominant and diagnostic herb, when its cover exceeds that of other undergrowth species and there is a lack of other indicators of more mesic conditions. Other species that are often found in the central and eastern portions of its range are *Achillea millefolium* var. *occidentalis*, *Carex filifolia*, *Carex inops* ssp. *heliophila*, *Koeleria macrantha*, and *Stipa comata*. In the western portion of the range of this community *Festuca idahoensis* may be present (Daubenmire 1952), but canopy cover in excess of 5% would be indicative of the more mesic *Pinus ponderosa* / *Festuca idahoensis* plant association. When shrubs are present they typically include *Chrysothamnus nauseosus* and, especially on sandy soils, *Rhus aromatica*.

The tree canopy structure, at least in the Alkali Creek study area, is that of a very open woodland, that verges on savanna though is technically not, due to tree cover being greater than that of any other lifeform. *Pinus ponderosa* ranges in cover from about 10% to approaching 30%. We did not note *Juniperus scopulorum* to occur on sandstone or sandstone colluvium but it is present as depauperate specimens in barely greater than trace amounts on fissile shales. The shrub component apparently varies according to parent material with *Rhus aromatica* and *Yucca glauca* found as a minor component on sandstone and *Sarcobatus vermiculatus* and *Atriplex confertifolia* found on fine textured sedimentaries. *Pseudoroegneria spicata* is the dominant graminoid though its cover is rivaled by, and occasionally exceeded by that of *Stipa comata*; their combined cover seldom exceeds 20%. Other high constancy graminoids include *Oryzopsis hymenoides* and *Carex filifolia*. We also noted that a transition from

sandstone to shale (or siltstone) substrates is accompanied by a shift to the appearance of or greater proportion of *Elymus lanceolatus*. The cover of *Bromus japonicus*, despite the open canopy and exposed ground, is present in only trace amounts. *Psoralea tenuiflora*, *Psoralea argophylla* and *Sphaeralcea coccinea* are the only forbs, excepting the exotic *Melilotus officinalis*, with greater than 50% constancy and also the only ones to occur in greater than trace amounts.

Dynamics: Despite the widely spaced trees and relative paucity, or at least patchy distribution, of fuels this type did experience predominantly stand-replacing fire in the course of the Alkali Creek burn. A more typically expected response when these conditions obtain in Fire Group Two (warm, dry *Pinus ponderosa* Habitat Types; Fisher and Clayton 1983) is an underburn or surface fire. The *Pinus ponderosa* of this community type in the Bull Mtns. and in Alkali Creek study area generally bore no fire scars. This observation probably reflects the light fuels condition for this type and may also point to the Alkali Creek Fire conditions being exceptional. The lack of *Juniperus scopulorum* in this type may be attributable to past fires killing this species and leaving the *Pinus ponderosa* overstory; this scenario has been documented by Culwell et al. (1991) in the Bull Mountains of central Montana.

Similar Associations:

Pinus ponderosa / *Festuca idahoensis* Woodland (CEGL000857)

Pinus ponderosa / *Stipa comata* Woodland (CEGL000879)

Pinus ponderosa / *Festuca kingii* Woodland (CEGL000186)

Synonymy: *Pinus ponderosa* / *Agropyron spicatum* Habitat Type (Clausnitzer and Zamora 1987, Cooper et al. 1987, Daubenmire 1952, Daubenmire 1970, Daubenmire and Daubenmire 1968, Hansen and Hoffman 1988, Hoffman and Alexander 1976, Jorgensen 1979, McLean 1970, Pfister et al. 1977, Steele et al. 1981) *Pinus ponderosa* / *Agropyron spicatum* Plant Association (DeVelle et al. 1995, Hall 1973, Johnson and Clausnitzer 1992, Johnson and Simon 1985, Johnson and Simon 1987)

Pinus ponderosa / *Agropyron spicatum* Type (Culwell et al. 1985, Western Technology and Engineering)

Pinus ponderosa / *Agropyron spicatum* Coniferous Forest (Thilenius et al. 1995)

GRank and Reasons: G4

Comments: This is a very broadly distributed association and consequently evidences considerable variability in structure and the undergrowth composition, especially the forb component. The stands used to document the *Pinus ponderosa* / *Pseudoroegneria spicata* Woodland Habitat Type described by Hansen and Hoffman (1988) and Hoffman and Alexander (1976) had very high basal area and densities for a woodland, possibly due to their sampling procedure. The dense structure may have affected the floristic makeup of the stands and made the list of dominant species a poor reflection of the community as a whole.

The Alkali Creek study area stands are some of the most open examples of this type yet described; Pfister et al. 1977 (for Montana exclusive of the Great Plains portion) and Steele et al. 1981 (for central Idaho) reported tree canopy cover to range between 20 and 60% and average 50% and 30% respectively. For Montana's Yellow Water Triangle (YWT) Jorgensen (1979) described the type as restricted to sandstone and having only 25% tree cover and 3% *Pseudoroegneria spicata* cover making the type on the YWT much more similar to that found on the study area. In the Bull Mountains (Culwell et al. 1991) this type's abiotic parameters, including landscape position and parent material, matches closely the circumstances in the Alkali Creek Fire area. Culwell et al. (1991) also refer to a phase of *Pinus ponderosa* / *Pseudoroegneria spicata* capable of supporting appreciable *Juniperus scopulorum* and another phase apparently outside the tolerances of this species. It is perhaps a telling observation that the type was not recorded in the habitat type inventory conducted by Roberts and Sibbersen (1979) on Bureau of Land Management holdings in the "Missouri Breaks" landscape; this may be attributable to the fact that only shale-derived soils were found in their study area.

ELEMENT DISTRIBUTION

Range: This ponderosa pine woodland is one of the drier ponderosa pine woodlands found in the northern Rocky Mountains, Intermountains, and extreme northwestern Great Plains of the United States

and Canada, extending from the Black Hills of South Dakota and Wyoming west to Oregon, Washington, and British Columbia.

Nations: CA, US

States / Provinces: BC: S2S3, ID: S3, MT: S4, ND: S2S3?, OR: S2, SD: S4, WA: S1, WY: S3?

ELEMENT SOURCES

Authors: Drake, J. F., WCS; Cooper, S. V. and C. Jean, MTNHP **Confidence:** 1 **Identifier:** CEGLO00865

References: Clausnitzer and Zamora 1987, Cooper et al. 1987, Culwell et al. 1985, Daubenmire 1952, Daubenmire 1970, Daubenmire and Daubenmire 1968, DeVelice et al. 1995, Hall 1973, Hansen and Hoffman 1988, Hoffman and Alexander 1976, Johnson and Clausnitzer 1992, Johnson and Simon 1987, Jorgensen 1979, McLean 1970, Pfister et al. 1977, Steele et al. 1981, Thilenius et al. 1995)

***Artemisia cana* / *Pascopyrum smithii* Shrubland**
Silver Sagebrush / Western Wheatgrass Shrubland

ELEMENT CONCEPT

Summary: This silver sagebrush shrubland is found in the northwestern Great Plains and Rocky Mountains of the western United States. Stands occur on flat alluvial deposits on floodplains, terraces or benches, or alluvial fans. The soils are moderately deep to deep and either silt loam, clay loam, or sandy loam. Flooding may occur periodically and this tends to retard soil development. This community is dominated by a combination of shrubs and graminoids. The total vegetation cover is moderate. The tallest and most conspicuous stratum in this community is a shrub layer that is usually 0.6-1.2 m.

Artemisia cana is the dominant in this layer and may be accompanied by *Symphoricarpos occidentalis*. Also present are shorter shrubs such as *Artemisia frigida*, *Krascheninnikovia lanata*, *Rosa woodsii*, and *Gutierrezia sarothrae*. The most abundant graminoid is *Pascopyrum smithii*. This species is typically 0.5-1.0 m tall. It is often accompanied by *Nassella viridula* and sometimes *Koeleria macrantha*, *Poa pratensis*, and *Stipa comata*. *Bouteloua gracilis* is the most abundant short graminoid. Typical forb constituents of this community are *Achillea millefolium*, *Gaura coccinea*, *Sphaeralcea coccinea*, and *Lactuca tatarica* var. *pulchella*.

Environment: This community occurs on flat alluvial deposits on floodplains, terraces or benches, or alluvial fans. The soils are moderately deep to deep (USFS 1992) and either silt loam, clay loam, or sandy loam (Johnston 1987, Hansen and Hoffman 1988). The soils may have moderate salt content (Hansen and Whitman 1938). Flooding occurs periodically and this tends to retard soil profile development (Hirsch 1985).

The distribution of this community on the Alkali Creek study area is in accord with the general description, being present on floodplains and lowest terraces.

Vegetation: This community is dominated by a combination of shrubs and graminoids. The total vegetation cover is typically moderate, but depends on frequency of flooding. The tallest and most conspicuous stratum is a shrub layer that is usually 0.6-1.2 m (Hansen and Hoffman 1988). The USFS (1992) found that on 14 stands in western North Dakota, shrubs averaged 28% canopy cover, graminoids 59%, and forbs 2%. Stands in Nebraska often have less than 15% cover. The variation in soils within and between stands of this community results in variable species composition. *Artemisia cana* is the dominant shrub. *Symphoricarpos occidentalis* is frequently present. There are also shorter shrubs such as *Artemisia frigida*, *Krascheninnikovia lanata*, *Rosa woodsii*, and *Gutierrezia sarothrae*. The most abundant graminoid is *Pascopyrum smithii*. This species is typically 0.5-1.0 m tall. It is often accompanied by *Nassella viridula* and sometimes *Koeleria macrantha*, *Poa pratensis*, and *Stipa comata*. *Bouteloua gracilis* is the most abundant short graminoid. Typical forb constituents of this community are *Achillea millefolium*, *Gaura coccinea*, *Sphaeralcea coccinea*, and *Lactuca tatarica* var. *pulchella*.

On the Alkali Creek study area this community exhibits a distinctly shrub herbaceous habit with *Artemisia cana* cover often not exceeding 15-20 % and total shrub cover (including *Chrysothamnus nauseosus* and *Symphoricarpos occidentalis*) being less than 25%. The undergrowth is consistently dominated by *Pascopyrum smithii*, which is highly variable in cover, ranging from approximately 10 to 60%. *Elymus lanceolatus* is usually present as scattered patches and where higher cover of *Nassella viridula* obtains may be indicative of areas having escaped past grazing pressure. Very minor populations of *Poa pratensis* and *Agropyron repens* have been noted.

Dynamics: Periodic flooding occurs in many stands of this community. On the Alkali Creek Fire study area *Artemisia cana* was noted to have sprouted from root crown adventitious buds, but rhizome sprouting was not noted. The extent of *Artemisia cana* mortality could not be determined however, burned and non-sprouting stumps in drainage bottoms (expected *Artemisia cana* habitat) were judged not

to be *Sarcobatus vermiculatus* and presumed not to be *Artemisia tridentata* spp. *wyomingensis*, but rather *Artemisia cana*.

Similar Associations:

Artemisia cana / *Elymus lanceolatus* – (*Nassella viridula*) Shrub Herbaceous Vegetation

Synonymy:

Artemisia cana / *Agropyron smithii* Habitat Type (Hansen et al. 1984) =

Artemisia cana Habitat Type (Hirsch 1985) =

Sagebrush Type (Hanson and Whitman 1938) =

Artemisia cana / *Elytrigia smithii* Plant Association (Johnston 1987) B

Artemisia cana - *Symphoricarpos occidentalis* / *Elytrigia smithii* Plant Association (Johnston 1987) =

Artemisia cana / *Agropyron smithii* Habitat Type (U.S. Forest Service (USFS) 1992) =

GRank & Reasons: G4 (96-02-01).

Comments: See Steinauer and Rolfsmeier (1997) for a description of the stands in Nebraska. On the Alkali Creek Fire study area the canopy cover of *Artemisia cana* is noted to be in the 5 to 20 % range, more characteristic of shrub herbaceous structure than shrubland.

ELEMENT DISTRIBUTION

Range: This silver or coaltown sagebrush shrubland is found in the northwestern Great Plains and Rocky Mountains of the western United States, ranging from Montana and North Dakota, south to Nebraska.

Nations: US

States/Provinces: MT:S4, ND:S2S3?, NE:S?, SD:SU

ELEMENT SOURCES

Authors: Drake, J. F., WCS; Cooper, S. V. and C. Jean, MTNHP **Confidence:** 1 **Identifier:** CEGLO01072

References: DeVelice et al. 1995, Hansen et al. 1984, Hansen et al. 1991, Hansen et al. 1995, Hanson and Whitman 1938, Hirsch 1985, Johnston 1987, Jorgensen 1979, Nelson 1961, Steinauer and Rolfsmeier 1997, U.S. Forest Service (USFS) 1992

***Artemisia tridentata* ssp. *wyomingensis* / *Elymus lanceolatus* Shrub Herbaceous**
Wyoming Big Sagebrush / Thickspike Wheatgrass Shrub Herbaceous

ELEMENT CONCEPT

Summary: This Wyoming big sagebrush community is found throughout the northern Great Plains and southward, with considerable distribution gaps owing perhaps to lack of inventory, to northern Colorado. Stands occur as extensive matrix types on level to gently rolling plains as well as small and large patches in dissected landscapes such as breaks and badlands. Soils are developed from various parent materials weathering to predominantly heavy-textured, clay-rich Aridisols and in more mesic conditions Mollisols. The vegetation is characterized by an open shrub layer dominated by *Artemisia tridentata* ssp. *wyomingensis* ranging in cover between 10 and 25%. *Chrysothamnus nauseosus* and *Artemisia frigida* are consistently present in amounts less than 5%, unless the community has experienced abusive grazing. *Elymus lanceolatus* is conventionally the dominant and diagnostic graminoid, though in exceptionally mesic representations it may have less cover than *Nassella viridula* or *Poa pratensis*. Other important associated graminoids include *Koeleria macrantha*, *Stipa comata*, *Bouteloua gracilis* and *Carex filifolia*. Total forb cover is low with the more constant species being *Sphaeralcea coccinea*, *Vicia americana*, *Achillea millefolium* and *Opuntia polyacantha*.

Environment: In southeastern Montana and Wyoming's Green River Basin this is a matrix type occurring over many square miles as a matrix type developed on extensive shale beds that weather to clays, silty clays, clay and silt loams. It also occurs as a small and large patch type in dissected terrain, usually on fine-textured sedimentary substrates, on upland positions with shallow to steep slopes of all but southerly aspects. Within some landscapes, it may be absent from northerly exposures, which potentially support *Pinus ponderosa*- or *Juniperus scopulorum*-dominated woodlands. The known range of soil reactions is between 7.2 and 8.0, except where developed on acid shales (pH in range of 4 to 5). In a generalized catena for Montana's Glaciated Plains this type can occur over most upland positions with steeper southerly exposures supporting *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* and giving way at toeslope positions to *Artemisia cana*-dominated communities in which *Pascopyrum smithii* is the often the graminoid dominant; *Elymus lanceolatus* can occur where flooding is intermittent but does not tolerate inundation or subirrigation as does *Pascopyrum smithii*.

Within the Alkali Creek study area this association is a small patch type found, as a potential vegetation type, primarily on upland flats (mini-mesas) and ridge crests. It is also represented as a small patch seral type on slopes of all aspects and degrees of inclination, though it is generally not found on lower slopes with north- through northeast-facing aspects. Soils are derived from shales, siltstones and rarely sandstone members of the Bearpaw Shale; in places a thin veneer of glacial drift is present. Usually the upper 20 cm of these profiles are essentially rock-free and have a clay loam to silt loam texture. Adjacent communities on the upland flats are usually a) *Pseudoroegneria spicata* – *Pascopyrum smithii* (*Elymus lanceolatus*) (with *Pascopyrum smithii* wholly replaced by *Elymus lanceolatus*) that often can be shown with an assiduous search for buried shrub stumps, to have been an *Artemisia tridentata* ssp. *wyomingensis* / *Elymus lanceolatus* community that was burned in some previous fire, b) *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* on thinner or sandstone-derived soils or more stressful positions, and c) pan spots with a high percentage of exposed soil and very scattered *Artemisia tridentata* ssp. *wyomingensis*. On slopes it intergrades with *Pinus ponderosa*- or *Juniperus scopulorum*-dominated stands.

Vegetation: *Artemisia tridentata* ssp. *wyomingensis* dominates the shrub layer, which may include minor amounts of *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, *Chrysothamnus nauseosus*, and the subshrub *Atriplex gardneri*. The undergrowth is dominated by *Elymus lanceolatus*, which is considered diagnostic when well represented (> 5 % canopy cover). Commonly occurring and occasionally co-dominant graminoids include *Koeleria macrantha*, *Stipa comata*, *Carex filifolia*, *Poa fendleriana*, and

Pascopyrum smithii. In the southern reaches of the type's distribution *Sitanion hystrix*, *Hilaria jamesii*, *Oryzopsis hymenoides* are additional consistently present graminoid components. The combined cover of forbs is usually low, less than 5%, however, richness of this component ranges from depauperate to highly diverse. Forbs with the highest constancy include *Cryptantha* spp., *Eriogonum* spp., *Astragalus* spp., *Castilleja* spp., *Phlox hoodii*, *Senecio integerrimus*, and *Opuntia polyacantha*.

In the Alkali study area total shrub cover ranged between 10 and slightly more than 20% with more than 90% of this contributed by *Artemisia tridentata* ssp. *wyomingensis*; thus the study area examples of this type are more appropriately termed shrub herbaceous. Other shrubs consistently present, though only exceptionally in more than trace amounts include *Sarcobatus vermiculatus*, *Gutierrezia sarothrae*, *Artemisia frigida* and *Atriplex confertifolia*. The canopy cover of the diagnostic graminoid, *Elymus lanceolatus*, ranges for the most part between 30 and 60% with other graminoids of high constancy being *Pseudoroegneria spicata*, *Bouteloua gracilis* and *Koeleria macrantha* and consistently represented by less than 10% cover. The alien annual grass, *Bromus japonicus*, is 100% constant and evidences a broad spectrum of cover values, from traces to greater than 30%. The forb component is relatively inconspicuous; rarely amounting to more than 3 % combined cover, and has only two species (*Opuntia polyacantha* and *Vicia americana*) that register greater than 75% constancy.

Dynamics: The vegetation and environment descriptions pertain to the potential natural vegetation expression of this association. Fire sweeping through these communities tends to completely consume the sagebrush, main stem and all, and even, ostensibly in the hottest of burns, dishing out the stem at ground level. The resulting community is described as the *Pseudoroegneria spicata* – *Pascopyrum smithii* (*Elymus lanceolatus*) association and *Elymus lanceolatus* and *Pseudoroegneria spicata* canopy cover approximates that of the pre-burn condition, though there may be an ephemeral fertilizer effect with more robust *Pseudoroegneria spicata* tussocks resulting. We found no Wyoming big sagebrush seedlings in any of the sites that had been sagebrush communities, nor anywhere at all in the study area, even areas immediately adjacent to existing communities wherein *Artemisia tridentata* ssp. *wyomingensis* is a significant component. We found at least one area that had been burned prior to the Alkali Creek fire and having the potential to support Wyoming big sagebrush; this site had no evidence of returning to sagebrush prevalence. We speculate that succession in this type would take considerably longer than the 10 to 20 year span commonly cited. In Wyoming Sturges (1984) stated a similar *Artemisia tridentata* ssp. *wyomingensis* community had recovered to pre-treatment sagebrush cover in approximately 11 years following treatment of a complete watershed however, Sturges obtained a very different result from test plots where complete control had been achieved. In test plots sagebrush remained an “extremely minor” component 20 years following treatment. The explanation of these seemingly contradictory results is that much sagebrush survived in the watershed treatment serving as seed source points whereas in the plots there was complete eradication requiring seed to drift in from some distance. In the Snake River Plains a post-burn sere was shown to require at least 20 years to attain pre-burn sagebrush density (Harniss and Murray 1973). In southwestern Montana Wambolt (2001) has also shown that fire in Wyoming big sagebrush is stand-replacing, killing or removing most of the aboveground vegetation and that recovery to pre-burn cover (of sagebrush) takes at least 20 years.

There is another portion of this association that occurs on sideslopes and generally more mesic positions that can usually be recognized by the presence of *Nassella viridula* and *Carex inops* ssp. *heliophila* and higher coverages of *Elymus lanceolatus*. We speculate these stands should be considered a seral representation that ultimately will progress through a stage wherein *Juniperus scopulorum* is strongly represented to dominant. *Pinus ponderosa* may be an early seral component with *Juniperus scopulorum* or it may reinvade the stand later in the sere to ultimately dominate the overstory producing a *Pinus ponderosa* – *Juniperus scopulorum* / *Carex inops* ssp. *heliophila* association.

Similar Associations:

Artemisia tridentata ssp. *wyomingensis* / *Pascopyrum smithii* Shrubland (CEGL001047)

Synonymy:

Artemisia tridentata ssp. *wyomingensis* / *Agropyron dasystachyum* Community (Jones 1992)

Artemisia tridentata ssp. *wyomingensis* / *Pascopyrum smithii* Habitat Type (Hansen and Hoffman 1988)

Artemisia tridentata / *Pascopyrum smithii* (*Elymus lanceolatus*) (Vanderhorst et al. 1998)

Artemisia tridentata / *Agropyron smithii* Habitat Type (DeVelice et al. 1995)

GRank & Reasons: G4

Comments: Based on the reported cover values for *Artemisia tridentata* ssp. *wyomingensis*, which were cited to not exceed 25%, the structural designation needs to be altered to “shrub herbaceous”. Should *Artemisia tridentata* ssp. *wyomingensis* / *Elymus lanceolatus* and *Artemisia tridentata* ssp. *wyomingensis* / *Pascopyrum smithii* be treated as ecological equivalents and merged? At least within the study area (Alkali Creek Fire, CM Russell Nat. Wildlife Refuge) there is a distinction between the distribution (ecology) of *Elymus lanceolatus* and *Pascopyrum smithii*, with *Elymus lanceolatus* in the uplands and *Pascopyrum smithii* in the drainages and draw bottoms. This distinction is anything but universal, with mixed populations of the two being common in southeastern Montana (Vanderhorst et al. 1998) and in some areas of northeastern Montana where the work of DeVelice et al. (1995) recognized *Pascopyrum smithii* and *Elymus lanceolatus* (formerly *Agropyron dasystachyum*) as ecological equivalents. In other areas, such as Sheridan County (Heidel et al. 2000), in studies that emphasized discriminating *Pascopyrum smithii* from *Elymus lanceolatus*, there is a fair degree of ecological separation of these two species with regard to landscape position and ecological setting.

ELEMENT DISTRIBUTION

Range: This community has been described from Colorado northward through the Green River Basin and other basins of south-central and northern Wyoming (Bighorn Basin) with a large gap in its documented distribution until it is documented from the Northern and Northwestern Glaciated Plains Sections of Montana.

Nations: US

States / Provinces: CO: SU, MT: S4?, WY: S4

ELEMENT SOURCES

Authors: Cooper, S. V., MTNHP **Confidence:** 2 **Identifier:** CEGl001044

References: Baker 1984, DeVelice et al. 1995, and Jones 1992

***Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* Shrub Herbaceous
Wyoming Big Sagebrush / Bluebunch Wheatgrass Shrub Herbaceous Vegetation**

ELEMENT CONCEPT

Summary: This bunchgrass vegetation type with an open Wyoming big sagebrush shrub layer occurs in western North Dakota, Montana, Wyoming, Colorado, Idaho, Washington, Oregon (apparently), Nevada, and British Columbia, Canada. It probably also occurs in Utah and it may occur in South Dakota. Stands occur on moderate to steep slopes at low to mid elevations, and on a variety of soils. Throughout the range of this association, the vegetation consists of an open to moderately dense shrub layer (about 10-25% canopy cover) dominated by *Artemisia tridentata* ssp. *wyomingensis*, and a herbaceous layer dominated by *Pseudoroegneria spicata* with lesser amounts of *Poa secunda* (sometimes a codominant grass). From the Great Plains westward to eastern Idaho and south to Colorado, the sagebrush seldom exceeds 0.5 meter in height, but in western Idaho and Washington, the shrubs typically are 1 meter tall. Other shrubs (especially *Chrysothamnus* sp.) and herbaceous species (especially *Stipa comata*) usually are present. *Festuca idahoensis* is absent or present in amounts too insignificant to be indicative of a more mesic environment. The stands in the eastern half of the geographic range often contain small amounts of *Gutierrezia sarothrae*, *Artemisia frigida*, *Sphaeralcea coccinea*, *Phlox hoodii*, *Koeleria macrantha*, and *Opuntia polyacantha*. Less constant species are *Bouteloua* spp. (especially *Bouteloua gracilis*), *Carex filifolia*, and *Pascopyrum smithii* (cover a small fraction of *Pseudoroegneria spicata* value). Missing from these eastern stands is *Stipa thurberiana*, though *Nassella viridula* is often present in minor amounts. In the western half of the geographic range, the vegetation generally lacks the associated species listed above and often contains *Antennaria dimorpha* and *Stipa thurberiana*. In addition, the stands in Washington often contain large amounts of crustose lichens as ground cover.

Environment: On the Great Plains of eastern Montana and Wyoming and western North Dakota (Hansen and Hoffman 1988, Thilenius et al. 1995, Jensen et al. 1992), stands of this association occur at 4400-5000 feet elevation on moderately steep to steep (16-45%) slopes and on gentle footslopes with various aspects, though southerly exposures tend to predominate. Soils are loams, sandy loams, and sandy clay loams, often with coarse fragments in the upper horizons. Stands on the Wyoming plains often are on slopes of sandstone or porcelanite buttes (Thilenius et al. 1995). In the basins and foothills of south-central Montana (DeVelice and Lesica 1993) and north-central and central Wyoming (Fisser 1964, Knight et al. 1987, Twit and Houston 1980), this association occupies mainly gentle to moderately steep (<35%) slopes at 4000-6000 feet elevation. Soils are moderately deep, usually loamy (although one stand has been described from a clay soil), may have a considerable volume of coarse fragments, and have low electrical conductivity. In central and north-central Montana this association ranges from being a matrix type on gently rolling terrain to a small patch type on restricted outcrops; it occurs where soils are weathered from coarse sedimentary material, principally sandstone, calcareous and otherwise. In central and northwestern Colorado, stands of this association occupy gentle to steep slopes (to 65%) on a variety of landforms at elevations from about 7000-8200 feet. Soils are derived from a variety of parent materials and often are gravelly. In southwestern Montana (Mueggler and Stewart 1980, Cooper et al. 1995), stands grow at elevations from 4000-7500 feet, on slopes up to 54% with various exposures. Soils are shallow to moderately deep and derived from a variety of parent materials. In eastern Washington (Daubenmire 1988), this association occupies silt loam and sandy loam soils on gentle to moderately steep (8-38%) slopes with a variety of aspects, up to about 2700 feet elevation. In British Columbia, this type grows on relatively warm, dry sites (Tisdale 1947), generally from 1300-1970 feet elevation with stands on steep, south-facing slopes occurring as high as 2950 feet (McLean 1970). Soils are loams, silt loams, and sandy loams.

This association is poorly documented within the Alkali Creek study area but appears to be exclusively a small patch type found only on sandstone outcrops or sandstone derived colluvium/alluvium. It is

documented from only mini-mesa tops or associated sandstone escarpments of various aspects. Often the remaining patches (following Alkali Creek Fire) are so small as to represent only a fragment of a community. Soils are apparently shallow, well-drained and of sandy to sandy loam texture. The relatively sparse vegetation cover is reflected in the lack of litter, usually less than 20%, and the high degree of exposed soils, gravel and rock (together averaging about 80%).

Vegetation: Throughout the range of this association, the vegetation consists of an open to moderately dense shrub layer (about 10-25% canopy cover) dominated by *Artemisia tridentata* ssp. *wyomingensis*, and a herbaceous layer dominated by *Pseudoroegneria spicata* with lesser amounts of *Poa secunda* (sometimes a codominant grass). Other shrubs (especially *Chrysothamnus* sp.) and herbaceous species (especially *Stipa comata*) usually are present. *Festuca idahoensis* is absent or present in amounts too insignificant to be indicative of a more mesic environment. The stands in the eastern half of the geographic range often contain small amounts of *Gutierrezia sarothrae*, *Artemisia frigida*, *Sphaeralcea coccinea*, *Phlox hoodii*, *Koeleria macrantha*, and *Opuntia polyacantha*. Less constant species are *Bouteloua* spp. (especially *Bouteloua gracilis*) *Carex filifolia*, and *Pascopyrum smithii* (Hansen and Hoffman 1988, Thilenius et al. 1995, Mueggler and Stewart 1980, DeVelice and Lesica 1993, Cooper et al. 1995, Tweit and Houston 1980, Fisser 1964, Knight et al. 1987, Baker and Kennedy 1985, Tiedemann et al. 1987). Missing from these stands is *Stipa thurberiana*, though *Nassella viridula*, somewhat of an ecological analogue, is often present in minor amounts. In the western half of the geographic range, the vegetation generally lacks the associated species listed above (although Tisdale (1947) reports *Artemisia frigida* in British Columbia) and often contains *Antennaria dimorpha* and *Stipa thurberiana* (Hironaka et al. 1983, Blackburn 1967, Blackburn et al. 1968, Daubenmire 1988, Tisdale 1947, McLean 1970). In addition, the stands in Washington often contain large amounts of crustose lichens as ground cover. Descriptions and photographs of stands show that shrub height also varies across the range of this type. From the Great Plains westward to eastern Idaho and south to Colorado, the sagebrush seldom exceeds 0.5 meter in height, but in western Idaho and Washington, the shrubs typically are 1 meter tall.

The upper canopy of this community has a open structure with the cover of *Artemisia tridentata* ssp. *wyomingensis* ranging from approximately 5 to 20%; even stands in which the oldest specimens are slightly over 40 years old have cover not exceeding 20%. Other shrubs species consistently present with a cover seldom greater than 1-3% are *Artemisia frigida*, *Gutierrezia sarothrae*, and *Chrysothamnus viscidiflorus*. The undergrowth is dominated by bunchgrasses with *Pseudoroegneria spicata* at approximately 5% or greater cover as diagnostic, though it and the other major graminoid, *Stipa comata*, average about 30 and 15% cover, respectively. *Carex filifolia*, *Koeleria macrantha*, and *Bouteloua gracilis* are consistently present, not exceeding about 5% cover. *Nassella viridula* is inexplicably consistently present, sometimes in greater than trace amounts. Usually *Nassella viridula* is indicative of mesic environments, whereas on study area sites of this relatively xeric association (having predominantly coarser textured soils and occurring on fractured bedrock) it may be exploiting the opportunity of deeper rooting and available soil moisture. The forb component is depauperate in both species number and in cover, which seldom exceeds 2 to 3 percent in the aggregate; *Phlox hoodii*, *Psoralea* spp. and *Opuntia polyacantha* are those forbs most consistently present.

Dynamics: Though the total vegetative cover is usually less than 50% and litter cover is also relatively light (< 20% of ground surface), this association apparently carried the Alkali Creek Fire quite effectively. The area in which this association was most extensive prior to the Alkali Creek Fire (or other fires) is now predominantly shrub-free grassland. Based on the trace amounts of *Bromus japonicus* in all inventoried, unburned stands of this type, we speculate that its pre-burn cover was probably minor as well in the areas that did burn. *Bromus japonicus* apparently did not experience a post-burn surge in cover. It is instructive to note that in southeastern Montana as well, disturbance of this association seems to result in only minor *Bromus japonicus* cover increases. These observations contrast with the results of disturbing (fire, grazing) the *Artemisia tridentata* ssp. *wyomingensis* / *Elymus lanceolatus* association, which usually responds with a prolific increase in *Bromus japonicus*. For the Snake River Plains representation of the *Pseudoroegneria spicata*-dominated type Hironaka et al. (1983) have noted over-

grazing does not result in nearly as prolific a response of *Bromus tectorum* (cheatgrass) as doe burning. This difference in response (to burning of this association) may be attributed to many factors but certainly raises the question as to the differential niches of the various annual brome grasses; if one is not present in the landscape of concern it may be advisable to see it remains so. The cover of native increaser species also has remained at low levels in the *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* type.

Similar Associations:

Artemisia tridentata / *Agropyron smithii* Habitat Type (Hansen & Hoffman 1988)

Synonymy:

Artemisia tridentata / *Agropyron spicatum* Habitat Type (Daubenmire 1970; Hansen and Hoffman 1988; Mueggler and Stewart 1980)

Artemisia tridentata / *Agropyron spicatum* Community Type (Mackie 1970)

Artemisia wyomingensis / *Agropyron spicatum* (Hironaka et al. 1983)

Artemisia wyomingensis / *Agropyron spicatum* Community (Jones 1992)

Artemisia tridentata ssp. *wyomingensis* / *Agropyron spicatum* Habitat Type (Jensen et al. 1992)

GRank & Reasons: G5?

Comments: Vegetation types that fit this association have been described from the Great Plains of western North Dakota, eastern Montana, and northeastern Wyoming on the east to southern interior British Columbia on the west, and as far south as northern Nevada and central Colorado. Based on differences in species composition, this association might be split into two associations or subassociations. The occurrences from the Great Plains west as far as northwestern Colorado, western Wyoming, and western Montana apparently belong to one association characterized by the presence of *Bouteloua* spp., *Carex filifolia*, *Koeleria macrantha*, *Gutierrezia sarothrae*, *Artemisia frigida*, and *Opuntia polyacantha*, and by the absence of *Achnatherum thurberianum* (= *Stipa thurberiana*). Occurrences from southern Idaho, northern Nevada, eastern Oregon, eastern Washington, and British Columbia might belong to a different type characterized by the presence of *Achnatherum thurberianum* and by the absence of the other species listed above. The division between these two associations probably would be made in Idaho. *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation (CEGL001535) has a thicker sagebrush layer (generally >25% canopy cover) and less relative cover of herbaceous species. *Artemisia tridentata* ssp. *wyomingensis* / *Poa secunda* Shrubland (CEGL001049) has an undergrowth dominated by *Poa secunda* and containing little *Pseudoroegneria spicata*. *Artemisia tridentata* ssp. *tridentata* / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation (CEGL001018) and *Artemisia tridentata* ssp. *vaseyana* / *Pseudoroegneria spicata* Shrubland (CEGL001030) differ in having shrub layers dominated by those subspecies of big sagebrush. This association is very broadly distributed (British Columbia south to Utah and Nevada, east to North Dakota) and shows considerable differences in composition across this range. In the eastern portion of this type's range *Koeleria macrantha*, *Bouteloua gracilis*, *Gutierrezia sarothrae*, *Artemisia frigida*, and *Opuntia polyacantha* are associated species and usually respond as increasers with grazing. In more western and southern regions overgrazing results in the dominance of *Poa secunda* and annual forbs/grasses.

ELEMENT DISTRIBUTION

Range: This association is known from Montana, Wyoming, Colorado, Idaho, Washington, Oregon (apparently), Nevada, and British Columbia, Canada. It also occurs in western North Dakota and Utah, and it may occur in South Dakota. This association is known to occur on the Thunder Basin National Grassland and on the Custer National Forest, Ashland District. It may also occur on the Sioux District and the Grand River Districts of the Custer National Forest.

Nations: CA, US

States / Provinces: AZ: SP, BC: S?, CA: S2, CO: S3?, ID: S3, MT: S3, ND: SP, NM: SP, NV: S4, OR: S3, SD: SP, UT: SP, WA: S3, WY: S4

ELEMENT SOURCES

Authors: WCS; Cooper, S.V. and C. Jean, MTNHP **Confidence:** 1 **Identifier:** CEGl001535

References: Baker 1983c, Baker and Kennedy 1985, Blackburn 1967, Blackburn et al. 1968b, Brown 1971, Cooper et al. 1995, Daubenmire 1970, Daubenmire 1988, DeVelice and Lesica 1993, Eckert 1957, Fisser 1964, Fisser 1970, Hansen and Hoffman 1988, Hess 1981, Hironaka et al. 1983, Jensen et al. 1992, Johnston 1987, Jones 1992, Knight et al. 1987, Lucky McMine Application n.d., McLean 1970, Mueggler and Stewart 1980, Northwest Resources Co. 1981, Seminole I Mine Application n.d., Smith n.d., Strong 1980, Thilenius et al. 1995, Tiedemann et al. 1987, Tisdale 1947, Tweit and Houston 1980

***Sarcobatus vermiculatus* / *Pascopyrum smithii* (*Elymus lanceolatus*) Shrub Herbaceous**
Black Greasewood / Western Wheatgrass – (Thickspike Wheatgrass) Shrub Herbaceous

ELEMENT CONCEPT

Summary: This greasewood shrub prairie is found in saline habitats in the northwestern Great Plains of the United States and Canada. Stands occur on flat to gently sloping alluvial fans, terraces, lakebeds, and floodplains. The soil is usually deep clay, silty clay, sandy clay, or loam, although coarse soils are possible. They are saline or alkaline, but salt crusts on the surface are typically absent. Parent material is usually alluvium. This community has moderate to dense vegetation cover. Medium-tall (0.5-1.5 m) shrubs are scattered throughout with a total shrub canopy of 10-25%. The shrub layer is dominated by *Sarcobatus vermiculatus*, with *Artemisia tridentata*, *Atriplex confertifolia*, and *Chrysothamnus viscidiflorus* in smaller amounts. *Symphoricarpos occidentalis* and *Rhus aromatica* are sometimes found in more mesic microhabitats within this community. Herbaceous cover is sparse beneath the shrubs and otherwise moderate to dense. The dominant species are typically 0.5-1 m tall. The most abundant species is *Pascopyrum smithii*, usually accompanied by *Bouteloua gracilis*, *Bromus japonicus*, *Bromus tectorum*, and *Stipa comata*. Few forbs are found in this community. *Achillea millefolium* and *Opuntia polyacantha* are the only species with high constancy. Overall species diversity in this community is low.

Environment: This community is found on flat to gently sloping alluvial fans, terraces, lakebeds, and floodplains (Mueggler and Stewart 1978, Hansen and Hoffman 1988). Dodd and Coupland (1966) found *Sarcobatus vermiculatus* in association with *Pascopyrum smithii* only on the most arid parts of southwestern Saskatchewan. The soil is usually deep clay, silty clay, sandy clay, or loam (Hirsch 1985, Jones and Walford 1995), although coarse soils are possible (USFS 1992, Thilenius et al. 1995). They are saline or alkaline, but salt crusts on the surface are absent (Thilenius et al. 1995, but see Steinauer and Rolfsmeier 1997). Parent material is usually alluvium. Flooding during the spring is possible.

Though this association occurs in small patches, these patches or linear arrays occur on adjacent ridge systems or are contiguous along footslopes or alluvial bottoms so as to never be far removed one from another, which then qualifies this as a matrix type, at least in the study area landscape. At the eastern edge of the study area this association occurs on footslopes and alluvial bottomlands on outwash materials derived from the rounded and eroded terrain immediately to the west and as part of the Musselshell River floodplains. However it also extends to upland positions, namely ridge shoulders and upper slopes irrespective of aspect or steepness. It occurs on only particular ridge systems, ostensibly those having parent materials with a unique chemistry that would produce somewhat higher alkali salt concentrations (mostly sodium?). Soils are derived from shale and siltstone and exhibit primarily loams and silt loams for alluvial positions and silty clay and silty clay loam textures on uplands with no or little stone content in the upper 20 cm. Characteristically the upland stands have much exposed soil, in excess of 80%, and many erosional features including rills and soil creep.

Vegetation: This community has moderate to dense vegetation cover (Jones and Walford 1995, Thilenius et al. 1995). Medium-tall (0.5-1.5 m) shrubs are scattered throughout, with a total shrub canopy of 10-25% (Hansen and Hoffman 1988, USFS 1992). The shrub layer is dominated by *Sarcobatus vermiculatus*, with *Atriplex confertifolia*, *Atriplex canescens*, *Atriplex argentea*, *Artemisia tridentata*, and *Chrysothamnus viscidiflorus* in smaller amounts. *Symphoricarpos occidentalis* and *Rhus aromatica* are sometimes found in more mesic microhabitats within this community (Hirsch 1985). Herbaceous cover is sparse beneath the shrubs and moderate to dense in between. The dominant species are typically 0.5-1 m tall. The most abundant species is *Pascopyrum smithii*, usually accompanied by *Bouteloua gracilis*, *Bromus japonicus*, *Bromus tectorum*, and *Stipa comata*. Few forbs are found in this community. *Achillea millefolium* and *Opuntia polyacantha* are the only species with high constancy. Other species present may include *Grindelia squarrosa*. Overall species diversity in this community is low (Hansen and Hoffman 1988, Von Loh et al. 1999). In Nebraska, shrub species cover may be very low, and saline

pockets may contain *Distichlis spicata* and *Sporobolus airoides*. *Astragalus bisulcatus* may be prominent (Steinauer and Rolfsmeier 1999).

In Alkali Creek, the diagnostic species are highly variable with *Sarcobatus vermiculatus* varying from approximately 3 to 20 % and *Elymus lanceolatus* ranging from 10 to 60 % plus. The higher canopy coverages (approaching 80% vegetative cover) are associated with the type as it occurs on downslope or outwash materials and upper slope/ridgeline examples have as little as 15 to 20% combined vegetative cover. The common shrub associates, seldom exceeding 5% cover, are *Artemisia tridentata* ssp. *wyomingensis*, *Artemisia cana* and, as reflection of unusual soil conditions, *Atriplex gardneri*. *Bouteloua gracilis* and the alien annual *Bromus japonicus* are the only graminoids with greater than 50% constancy. The forb component is quite depauperate; except for the occasional patch of the introduced *Melilotus officinalis* contributing more than 5% cover, the four or five other forbs seldom exceed 1-3% combined cover.

Dynamics: Unlike the *Artemisia* component of this association, which is completely obliterated by fire, *Sarcobatus* was noted to resprout from its root crown, especially in the upslope stands where fuel loading would have been less than in the footslope communities having abundant fuels (and thus hotter burns). It is difficult to specify the graminoid fire response in any detail, but ostensibly the post-burn cover of *Elymus lanceolatus* is at least as great as that of the pre-burn (Wright and Bailey 1982). The post-burn communities appear almost indistinguishable from many stands of the *Pseudoroegneria spicata* – *Pascopyrum smithii* – (*Elymus lanceolatus*) or *Elymus lanceolatus* – *Nassella viridula* associations, except that *Sarcobatus vermiculatus* / *Pascopyrum smithii* – (*Elymus lanceolatus*) has on average reduced grass cover and *Nassella viridula* is not present. This association was notable for having some of the highest cover of *Bromus japonicus*, both un-burned and most especially as a post-burn response. Similarly high *Bromus japonicus* cover was shown for this association in the work of Hansen and Hoffman (1988) and by Mueggler and Stewart (1977). The post-burn response for Alkali Creek area was inferred from the fact that observed un-burned stands had *Bromus japonicus* cover values never were as high as those of the burned stands. This is a weak inference; we did search extensively for paired stands (spatially proximal), burned and unburned, but the Alkali Creek Fire did not leave many upslope positions unburned. Only a pre-burn cover or biomass measurement followed by fire can supply the answer.

Similar Associations:

Sarcobatus vermiculatus / *Pseudoroegneria spicata* Shrubland (CEGL001367)

Sarcobatus vermiculatus / *Elymus elymoides* - *Pascopyrum smithii* Shrubland (CEGL001365)

Sarcobatus vermiculatus / *Distichlis spicata* - (*Puccinellia nuttalliana*) Shrub Herbaceous Vegetation (CEGL002146)

Synonymy:

Sarcobatus vermiculatus / *Agropyron* spp. Habitat Type (Mackie 1970)

Sarcobatus vermiculatus / *Agropyron smithii* Habitat Type (Mueggler and Stewart 1980; Hansen and Hoffman 1988, Hansen et al. 1995, Jensen et al. 1992)

Sarcobatus vermiculatus / *Agropyron smithii* Plant Association (DeVelice et al. 1995)

Sarcobatus vermiculatus / *Agropyron dasystachyum* Habitat Type (Jorgensen 1979)

GRank & Reasons: G4

Comments: It should be noted that the global description of this association makes no mention of *Elymus lanceolatus* as an alternative diagnostic species, much less the fact that it can be dominant as is the case on the Alkali Creek Fire study area and throughout much of northcentral and northeastern Montana. This association, or closely related permutations, has heretofore been described as occurring in bottomland areas with alluvial soils; in this study we have found the type on both alluvial outwash and upland positions as well. The vegetative cover varies by habitat, being greater on footslopes and bottomlands, but the composition is essentially the same in both environments and their response to disturbance, though weakly documented, appears to be quite similar. We see no need at this point to distinguish these somewhat contrasting environments though in the future a landscape term could be appended to the name for increased specificity.

Compare this association with *Sarcobatus vermiculatus* / *Elymus elymoides* - *Pascopyrum smithii* Shrubland (CEGL001365) from New Mexico.

See Steinauer and Rolfsmeier (1997) for a description of the stands in Nebraska. *Sarcobatus vermiculatus* / *Distichlis spicata* - (*Puccinellia nuttalliana*) Shrub Herbaceous Vegetation (CEGL002146) may be a more saline version of this type.

ELEMENT DISTRIBUTION

Range: This greasewood shrub prairie is found in saline habitats in the northwestern Great Plains of the United States and Canada, ranging from northwestern Nebraska north to the Dakotas and Saskatchewan.

Nations: CA, US

States / Provinces: MT: S4, ND: S4?, NE: S2, SD: SU, SK: SP, WY: S4

ELEMENT SOURCES

Authors: WCS, Cooper, S. V. and C. Jean, MTNHP **Confidence:** 1 **Identifier:** CEGL001508

References: Brown 1971, DeVelice et al. 1995, Hansen and Hoffman 1988, Hansen et al. 1995, Jensen et al. 1992, Mueggler and Stewart 1980

***Symphoricarpos occidentalis* Shrubland**

Western Snowberry Shrubland

ELEMENT CONCEPT

Summary: This western snowberry shrubland is found in the western tallgrass and northern Great Plains of the United States and Canada. Stands occur in mesic depressions and swales, typically surrounded by upland grassland communities. The soils are silts and loams. Potentially this type has three distinct vegetation layers, a shrub layer (approximately 80 cm tall), a graminoid-dominated layer (approximately 30 cm tall), and a forb-dominated layer (<20 cm tall). *Symphoricarpos occidentalis* is the predominant species in the shrub layer and at times forms almost monospecific stands. *Rosa woodsii* commonly occurs interspersed with the *Symphoricarpos occidentalis*. Other shrubs, such as *Rhus aromatica* and *Prunus virginiana*, often occur as thickets on the fringe of this community. *Rhus aromatica* and *Prunus virginiana* can reach 2 m or more. The herbaceous layer is poorly represented where the shrubs are dense, although *Poa pratensis* occurs in many stands. Common forbs include *Artemisia ludoviciana*, *Solidago* spp., and *Achillea millefolium*. Vines, such as *Parthenocissus vitacea*, are often found climbing through the shrubs. This type is frequently observed in heavily grazed meadows and prairies.

Environment: This community is found in mesic swales, depressions, ravines and floodplains. Some examples of this community experience intermittent and brief flooding. The soils are fertile and well-drained to imperfectly drained silts and loams. The upper soil horizon is usually deep, although a thin layer of sand may be present if the site has been recently flooded (Jones 1995).

Vegetation: Throughout its range this community is dominated by shrubs approximately 1 m tall. Shrub cover is typically greater than 50%, and in places it can approach 100%. These shrubs form dense clumps that exclude most other species. *Symphoricarpos occidentalis* is the most common shrub, but *Rhus aromatica* (or *Rhus trilobata*) and *Prunus virginiana* can be locally abundant and can grow to 2-3 meters in places. *Toxicodendron rydbergii* may also be present. Herbaceous species and smaller shrubs are most abundant at the edges of this community and in gaps between the clumps of taller shrubs where the shading is less complete. *Rosa woodsii* is a typical smaller shrub. Common graminoids include *Pascopyrum smithii* and *Poa pratensis*. *Achillea millefolium*, *Artemisia ludoviciana*, *Galium boreale*, and *Solidago* spp. are common forbs of this community. Woody vines sometimes occur, including *Parthenocissus vitacea*.

Dynamics: Stands may occasionally be flooded (Jones 1995). *Symphoricarpos occidentalis* seems to thrive in disturbed areas (Hansen and Hoffman 1988), especially those subject to disturbance by fire and cattle grazing. On the Alkali Creek Fire due to abundant root crown and rhizome sprouting *Symphoricarpos occidentalis* stem density appears greater on burned than unburned areas. *Nassella viridula* (green needlegrass) appears to have decreased in burned areas.

Similar Associations:

Fraxinus pennsylvanica - *Ulmus americana* / *Prunus virginiana* Woodland (CEGL000643)--Related in terms of habitat; floristically distinct.

Synonymy:

Symphoricarpos occidentalis Community (Hansen et al. 1984) =

Low Shrub (Meyer 1985) =

Symphoricarpos occidentalis / *Elytrigia smithii* Plant Association (Johnston 1987) =

Symphoricarpos occidentalis Community (Hansen et al. 1984) =

Symphoricarpos occidentalis Community (Jones and Walford 1995) =

Symphoricarpos occidentalis Series (Jones 1992) =

GRank & Reasons: G4G5 (96-02-01). This type is common throughout the northern Great Plains. Historically, it may never have been very extensive. It has been observed to grow out from forest or woodland edges and shade out the grasses. It is tolerant of both grazing and fire (Hansen and Hoffman 1988), and is under no threat from human activities. In some cases, heavily grazed pastures may favor this

type. Many examples are somewhat weedy and others, while not weedy, have had the grass component reduced or virtually extirpated. Thus the type is demonstrably secure but high quality examples may become uncommon.

Comments: This type often occurs in heavily disturbed areas in conjunction with exotic species such as *Poa pratensis* and *Cirsium arvense*. Because it occurs in mesic swales, depressions, ravine bottoms and floodplains, some stands are occasionally flooded whereas others are just very moist. Thus it tends to fall on both sides of the upland/wetland division.

On the Alkali Creek Fire study area this is a minor type occurring as narrow stringers along toeslope positions and extending onto alluvial flats. On north-facing slopes *Symphoricarpos occidentalis* and *Rosa woodsii* extend up upslope varying distances beneath a canopy of *Pinus ponderosa* to define a narrow ecotone of the *Pinus ponderosa* / *Symphoricarpos occidentalis* (CEGL000204) association between *Symphoricarpos occidentalis* below and *Pinus ponderosa* – *Juniperus scopulorum* / *Carex inops* association above. It appears historic grazing pressure on the graminoid component (particularly *Nassella viridula*, *Elymus lanceolatus*, and *Pascopyrum smithii*) has left some stands grass depleted (with rest they should recover) or converted to *Poa pratensis* undergrowth dominance. Often the abundance of *Rosa woodsii* rivals that of *Symphoricarpos occidentalis*.

ELEMENT DISTRIBUTION

Range: The western snowberry shrubland is found in the western tallgrass and northern Great Plains of the United States and Canada.

Nations: CA, US

States/Provinces: CO:S3, IA?, MB?, MT:S4S5, ND:S4?, NE:S4, SD:SU, SK:S?, WY:SR

ELEMENT SOURCES

Authors: Drake, J. F., WCS **Confidence:** 3 **Identifier:** CEGL001131

References: Christy 1973, Clark 1977b, Clark et al. 1980, Hansen et al. 1984, Hansen et al. 1991, Hansen et al. 1995, Johnston 1987, Jones 1992, Jones and Walford 1995, Kittel et al. 1994, Kittel et al. 1999, McAdams et al. 1998, Meyer 1985, Steinauer and Rolfsmeier 1997

***Elymus lanceolatus* – *Nassella viridula* Herbaceous Vegetation**

Thickspike Wheatgrass – Green Needlegrass Herbaceous Vegetation

ELEMENT CONCEPT

Environment: We have segregated *Elymus lanceolatus* – *Nassella viridula* from *Pascopyrum smithii* – *Nassella viridula* due to an increased understanding of the ecologies of the component species. *Elymus lanceolatus* – *Nassella viridula* was probably a major community type throughout the northwestern Great Plains (Coupland 1961) but has been put to the plow because of its favorableness for agriculture. Its occurrence is also much reduced and degraded because the gentle terrain affords ready access to livestock. *Elymus lanceolatus* – *Nassella viridula* is found on a broad variety of topographic positions, from rolling upland of low to moderate relief to swales, breaklands, and moderate to steep, cooler aspects of coulees. It occurs on protected exposures, moister or water receiving positions in the landscape that possess fine-textured soils, though frequently a thin mantle of glacial drift may cover the sedimentary substrates which provide the majority of rooting medium. This type often grades to *Stipa comata* – *Bouteloua gracilis*, *Stipa comata* – *Carex filifolia* or *Pascopyrum smithii* – *Bouteloua gracilis* on adjacent uplands and *Artemisia cana* -dominated or *Symphoricarpos occidentalis* communities on lowland positions. Intensive grazing of this association has resulted in much conversion to *Stipa comata* – *Bouteloua gracilis* and *Pascopyrum smithii* – *Bouteloua gracilis* plant associations or weed-dominated community types with a high percentage of introduced annual grasses (*Bromus japonicus*, *Bromus tectorum*, *Festuca octoflora*, etc.).

Within the Alkali Creek study area this is a important matrix community type, which may represent both an early seral condition of shrubland and woodland plant associations, as well as a potential natural vegetation type (described herein). It is associated with relatively mesic landscape positions or conversely strongly and negatively associated with those most heat- and moisture-stressed, such as steep south- through west-facing slopes, the uppermost positions of hills and ridges, particularly those classed as shedding surfaces, such as slope shoulders. Within the dissected study area topography it occurs in lower positions often extending from gully or shallow ravine) bottoms to approximately midslope. Within the study area it occurred on soils derived from both fine textured sedimentaries (drift mantled in places) and sandstone. On sandstone sites it occurred only near slope bottoms or on north exposures.

Vegetation: *Elymus lanceolatus* and *Nassella viridula* occurring well represented are diagnostic for this type, however fenceline contrasts indicate that both species can be reduced to trace amounts and even extirpated by intensive grazing. Ascertain the intensity of grazing before relaxing cover criteria for type identification. On lightly grazed rolling terrain *Elymus lanceolatus* cover approaches 95%. *Nassella viridula* was chosen as an indicator of "favorable habitats" being associated with "heavy soil, by protection from wind, or by extra moisture from runoff." (Coupland 1961); where not abusively grazed, *Nassella viridula* cover may approach 20%. *Bouteloua gracilis* and *Carex filifolia* (*Stipa comata* on sites with better drainage) are capable of dramatic increase with grazing and prolonged drought (Coupland 1961). Various mixes of *Carex* spp. (*Carex stenophylla*, *Carex filifolia*, *Carex heliophila*) and *Koeleria cristata* are highly constant and range widely in cover values. *Selaginella densa* cover is high (> 70%) on some severely overgrazed lands; other overgrazed sites support only trace amounts. High constancy forbs include *Phlox hoodii*, *Sphaeralcea coccinea*, *Antennaria parviflora*, *Vicia americana* and *Psoralea argophylla*. *Artemisia frigida* is the only shrub with greater than 50% constancy; on overgrazed pastures its cover approaches 20%.

On lightly grazed rolling terrain of the study area *Elymus lanceolatus* cover approaches 80% and in favorable microsites, not abusively grazed, *Nassella viridula* cover verges on 20%. *Carex inops* ssp. *heliophila* and *Pseudoroegneria spicata* are the other native graminoids most consistently associated with this type, though their cover usually does not exceed 5%. *Bromus japonicus* is ubiquitously present,

responding as a disturbance increaser (see **Dynamics** section). Close inspection reveals a relatively obscure forb component including the highly constant *Psoralea argophylla*, *Vicia americana*, *Achillea millefolium* and *Collomia linearis*; these are the principal forbs that occurred in greater than trace amounts. *Selaginella densa* is conspicuously and inexplicably absent in this landscape's examples of this community type. Shrubs are scarce with only traces of *Artemisia frigida* and *Rhus aromatica* noted; this extremely poor representation of shrub and sub-shrub component may be a clue pointing to these sites having been burned in the Alkali Creek fire.

Dynamics: Observation of postfire succession in northern Montana indicates that four years following a burn the dwarf-shrub component had yet to establish. Regarding response of grasses, lack of preburn inventory renders observations as mere conjecture, but rhizomatous grass cover of burned areas appeared more lush with greater biomass than unburned. There appeared to be no increased mortality for bunchgrasses, rather they appeared taller and more robust.

Native disturbance increasers (e.g. *Collomia linearis*, *Hedeoma hispidula*, *Lepidium* spp.) are a minor, non-threatening component, but Eurasian aliens (e.g. *Camelina macrocarpa*, *Melilotus officinalis*, *Bromus japonicus*, *Bromus tectorum*) constitute a significant liability to community integrity and values. *Bromus japonicus* currently constitutes the greatest threat to native diversity due to its considerable presence in the landscape. If an analogy can be made between the ecology and disturbance response of *Bromus japonicus* and that of *Bromus tectorum*, then with successive fires (or continued abusive grazing practices) *B. japonicus* will markedly increase its cover relative to that of the native species component (Mack 1984). The aggressiveness of the biennial *Melilotus officinalis* is much greater than originally appreciated, when it was used indiscriminately to revegetate burns and other disturbances and planted as dense nesting cover.

As noted above it is nearly impossible, four years post-fire, to ascertain exactly what portions of the Alkali Creek grassland have been burned and certainly attributing intensity to the burn (temperatures generated and their duration) is yet more challenging. With hot fires bunchgrasses can suffer reduced vigor and mortality; however one must have a pre-burn inventory to attribute consequences to fire; four years postfire the Alkali Creek bunchgrasses appeared robust and there was indication of increased mortality. We accumulated insufficient quantitative evidence to unequivocally say that, by comparison to composition of this type in the adjacent unburned landscape, particular portions of Alkali Creek study area had not experienced fire. However, anecdotal information, such as the greater coverage of *Artemisia frigida* and *Gutierrezia sarothrae* in adjacent, unburned stands of *Elymus lanceolatus* – *Nassella viridula* points to most of the Alkali Creek Landscape grasslands having been burned. *Bromus japonicus* currently constitutes the greatest threat to native diversity due to considerable presence in the landscape. If an analogy can be made with the ecology and disturbance response of the weedy annual *Bromus tectorum* (cheatgrass) then with successive fires (or continued abusive grazing practices) *Bromus japonicus* will markedly increase its cover relative to that of the native species (Mack 1984). The aggressiveness of the biennial *Melilotus officinalis* is much greater than originally appreciated; within the refuge it has increased remarkably within this association on Knox Ridge and gives no indication of abating with time. Thus the successional diagram for fire in grasslands of this area shows a very simplistic pathway for fire in the absence of alien species, with post-burn recovery resulting in a community, within stochastic limits, not recognizably different from the pre-burn representation.

Similar Associations:

Elymus lanceolatus - (*Koeleria macrantha*) Herbaceous Vegetation (CEGLMTHP39; Heidel et al. 2000)

Elymus lanceolatus - *Elymus trachycaulus* Herbaceous Vegetation (CEGLMTHP58; Cooper et al. 2001)

Pascopyrum smithii – *Nassella viridula* Herbaceous Vegetation (CEGL001583)

Pascopyrum smithii – *Carex filifolia* Habitat Type (portions of; Hansen and Hoffman 1988)

GRank & Reasons: G3G4?

Comments: This association has only recently been recognized with the accumulation of information from several northeastern Montana counties (Heidel et al. 2000, Cooper et al. 2001) and southern portions of Canada's prairie provinces (Coupland 1992) that indicates the ecology of *Elymus lanceolatus* to differ from that of *Pascopyrum smithii*, at least in regard to some portions of the range where they are sympatric. In the Alkali Creek study area *Pascopyrum smithii* appears to favor drainage bottoms and the lowest portions of toeslopes, whereas *Elymus lanceolatus* is most abundantly represented on the fine-textured, though well-drained, soils of the uplands. *Nassella viridula* is extremely palatable and susceptible to intensive grazing; it has been employed as a diagnostic species because of its strong fidelity to mesic environments. In the Alkali Creek Landscape its presence serves to distinguish *Elymus lanceolatus* – *Nassella viridula* from *Pseudoroegneria spicata* – *Pascopyrum smithii* (*Elymus lanceolatus*).

The following description is written not knowing whether the particular plots and notes from which the description derives reflect a post-burn response; fire burning through an herbaceous type leaves no semi-permanent clues to its passage (it is truly stand-replacing). We would assume, given the appreciable amount and continuity of fuels present in the grassland portion of the landscape at the time of this inventory, that virtually all of the grassland did burn.

ELEMENT DISTRIBUTION

Nations: US

States/Provinces: MT:S3S4?

ELEMENT SOURCES

Authors: Cooper, S. V. and C. Jean, MTNHP **Confidence:** 2 **Identifier:** CEGLMTHP57

***Hordeum jubatum* Herbaceous Vegetation**
Foxtail Barley Herbaceous Vegetation

ELEMENT CONCEPT

Summary: This foxtail barley community type is found in the northern and central Great Plains of the United States and Canada, in lowlands with moderately to strongly saline soils. The topography is flat and the soils are often flooded or saturated in the spring. The vegetation is dominated by short and medium tall graminoids with a total vegetation cover of nearly 100%. Shrubs are usually absent.

Hordeum jubatum dominates the community. Other common species in this community are *Elymus trachycaulus*, *Distichlis spicata*, *Pascopyrum smithii*, *Poa arida*, *Poa compressa*, *Rumex crispus*, and *Sonchus arvensis*.

Environment: Stands are located in lowlands with moderately to strongly saline soils (Barnes 1978). The topography is flat or gently sloping and the soils are often flooded or saturated in the spring (Redmann 1972). In the Alkali Creek study area these sites comprised small patches confined to the bottoms of steep-sided draws as well as outwash flats at the lower ends of these drainages.

Vegetation: The vegetation is dominated by short and medium-tall graminoids with a total vegetation cover of nearly 100% (Barnes 1978). Shrubs are usually absent except where this type grades to *Symphoricarpos occidentalis* and *Rosa woodsii* communities immediately upslope. *Hordeum jubatum* dominates the community, occasionally almost monospecifically; other common species in this community include, in approximate declining order of importance, *Pascopyrum smithii*, *Distichlis spicata*, *Elymus trachycaulus*, *Poa arida*, *Poa compressa*, *Rumex crispus*, and *Sonchus arvensis*.

Alkali Creek Study examples of this type are species poor, strongly dominated by *Hordeum jubatum* with *Pascopyrum smithii* ranging from a co-dominant to barely represented. *Poa cusickii* (Cusick's bluegrass), *Poa secunda* (formerly *Poa juncifolia*, alkali bluegrass) and *Puccinellia nuttalliana* (Nuttall's alkali grass) are consistently present in low coverage. The only forbs noted are *Rumex crispus* (western dock) and *Grindelia squarrosa* (curlycup gumweed).

Dynamics: The Alkali Creek Fire obviously burned across these areas (on north-south trending drainages woodlands on both east and west banks evidenced fire effects for a fire pushed by winds from the west) but four years post-fire it appears the effects were minimal, other than the consumption of fine fuels and perhaps a fertilizer effect that has persisted.

Similar Associations:

Distichlis spicata - *Hordeum jubatum* - *Puccinellia nuttalliana* - *Suaeda calceoliformis* Herbaceous Vegetation (CEGL002273)

Synonymy:

Hordeum Type (Redmann 1972) = uncertain if equivalent

Foxtail Barley Community (Barnes and Tieszen 1978) = uncertain if equivalent

GRank & Reasons: G4 (96-02-01).

Comments: This type is poorly defined. This abstract is based on two descriptions of *Hordeum jubatum*-dominated stands that are assumed to be examples of this community. These stands may be variants of *Distichlis spicata* - *Hordeum jubatum* - *Puccinellia nuttalliana* - *Suaeda calceoliformis* Herbaceous Vegetation (CEGL002273). The relationship between *Hordeum jubatum* Herbaceous Vegetation (CEGL001798) and that type is unclear. Both communities usually contain *Distichlis spicata* and *Hordeum jubatum* in varying amounts. The presence of *Puccinellia nuttalliana* or *Suaeda calceoliformis* may be distinguishing factors. They appear to be more characteristic of strongly saline areas while *Hordeum jubatum* can dominate on less saline sites (Redmann 1972). Classification problems may arise on intermediate sites when *Hordeum jubatum* is the dominant species and *Distichlis spicata*, *Puccinellia nuttalliana*, and *Suaeda calceoliformis* are present in minor amounts.

Element Distribution

Range: This foxtail barley community type is found in the northern and central Great Plains of the United States and Canada, ranging from Colorado to Saskatchewan.

Nations: CA, US

States/Provinces: CO:S3?, MT:S4, ND:S?, SD?, SK:S?

Element Sources

Authors: Drake, J. F., WCS **Confidence:** 3 **Identifier:** CEG001798

References: Barnes and Tieszen 1978, Bunin 1985, Hansen et al. 1991, Redmann 1972, Reid 1974, Vestal 1914

***Pascopyrum smithii* Herbaceous Vegetation**
Western Wheatgrass Herbaceous Vegetation

Element Concept

Summary: This midgrass prairie type is found in the northern and western Great Plains, Rocky Mountains, and western basins of the United States and possibly Canada. Stands occur on level to gently sloping terrain. They are sometimes found on alluvial fans. The soils are clay, clay loam, and silt loam. The dominant mixed grass species grow to approximately 1 m. *Pascopyrum smithii* may have as much as 50% coverage. Other grasses that co-occur and may achieve local dominance are *Koeleria macrantha* and *Poa* spp. Many other species common in midgrass prairies are also found in this community. These include *Artemisia ludoviciana*, *Bouteloua gracilis*, *Nassella viridula*, and *Stipa comata*. This community is similar to several others that have significant amounts of *Pascopyrum smithii*. Further work needs to be done to better define the diagnostic characteristics of this community.

Environment: This community occurs on flat to gently sloping topography. Soils are clay, clay loam, and silt loam. It is sometimes found on alluvial fans of small streams. The soils are deep (40-100 cm) and well-developed.

Vegetation: This is a midgrass community. Shrubs are rare. The dominant species grow to approximately 1 m. *Pascopyrum smithii* is the only constant dominant species and may have 50% cover. Other species such as *Koeleria macrantha* and *Poa* spp. may be locally abundant. Many other species common in midgrass prairies are also found in this community. These include *Artemisia ludoviciana*, *Bouteloua gracilis*, *Nassella viridula*, and *Stipa comata*.

Similar Associations:

Pascopyrum smithii - *Nassella viridula* Herbaceous Vegetation (CEGL001583)

Synonymy:

Wheatgrass (Aldous and Shantz 1924) =

Agropyron smithii Great Basin Grassland (Baker and Kennedy 1985) =

GRank & Reasons: G3G5Q (96-02-01).

Comments: This community is similar to several others that are dominated or codominated by *Pascopyrum smithii*. As currently defined, it represents a western Great Plains and foothills version of the western wheatgrass types in the central Great Plains. Further work needs to be done to refine the differences in composition and environmental characteristics. See recent descriptions by Thilenius et al. (1995, "*Pascopyrum smithii* sodgrass steppe," a more playa-like wheatgrass type) and by Steinauer and Rolfsmeier (1997). In Nebraska, Steinauer and Rolfsmeier (1997) suggest that their stands may resemble *Pascopyrum smithii* - *Nassella viridula* Herbaceous Vegetation (CEGL001583).

Element Distribution

Range: This midgrass prairie type is found in the northern and western Great Plains, Rocky Mountains and western basins of the United States and possibly Canada, ranging from North Dakota and possibly Saskatchewan, south to Nebraska and Colorado, west to Utah, and north to Idaho.

Nations: CA, US

States/Provinces: AZ:S?, CO:S1?, ID:S1Q, MT:S4, NE:S?, SD:S?, SK:S?, UT:S3S5, WY:S4Q

TNC Ecoregions: 10:C, 11:C, 26:C, 27:C, 6:C, 9:C

USFS Ecoregions: 331D:CC, 331F:CC, 331G:CC, 331H:CC, 331I:CC, 342F:CC, M331A:CC, M332E:CC

Element Sources

Authors: Drake, J. F., WCS **Confidence:** 3 **Identifier:** CEGL001577

References: Aldous and Shantz 1924, Baker 1983c, Baker and Kennedy 1985, Bunin 1985, Christensen and Welsh 1963, Godfread 1994, Hansen et al. 1991, Marr and Buckner 1974, Ramaley 1916, Ramaley 1919, Ramaley 1942, Shanks 1977, Soil Conservation Service 1978, Thilenius et al. 1995

***Pseudoroegneria spicata* – *Pascopyrum smithii* (*Elymus lanceolatus*) Herbaceous Vegetation**
Bluebunch Wheatgrass – Western Wheatgrass (Thickspike Wheatgrass) Herbaceous Vegetation

ELEMENT CONCEPT

Environment: This association occurs as a large patch to matrix type within the study area and is most typically associated with upland benches, mini-mesas and upper slopes of ridge systems. On slopes it is more associated with warmer aspects and is noted to be most extensive on southerly exposures where it ranges from the upper edge of toeslope positions to ridge crests. It occurs on both sandstone exposures associated with the mesa caps and shale and siltstone that occasionally have a veneer of glacial drift. Soils range from sandy loams to clay and silt loams derived from the fine-textured sedimentaries. The amount of exposed substrate varies widely depending on position, with lower slopes having less than 5% soil exposed to upper slopes, particularly shoulders and crests having 80% or more soil and gravel exposed. This association grades to *Elymus lanceolatus* – *Nassella viridula* on sites having greater effective moisture and to *Sarcobatus vermiculatus* / *Pascopyrum smithii* – (*Elymus lanceolatus*) where soil chemistry changes toward a more alkaline reaction. In the proximity of sites developed on sandstone this association does grade to what are usually small patches of the *Pseudoroegneria spicata* – *Stipa comata* association on thin soils or warmer and exposed microsite positions.

Vegetation: This type is defined by *Pseudoroegneria spicata* and either *Pascopyrum smithii* or *Elymus lanceolatus* being well represented. Even within the limited confines of the study area, wide variation in cover values were noted for the diagnostic grasses with *Pseudoroegneria spicata* exhibiting increasing cover, both absolute and relative to that of *Elymus lanceolatus*, following a moisture/exposure gradient from lower slopes to ridge shoulder/crest. Even the most exposed sites, if developed on fine-textured sedimentaries, exhibit at least 5% *Elymus* cover, though often this is less than that exhibited by *Pseudoroegneria spicata*. Graminoids with high constancy include *Bouteloua gracilis*, *Carex stenophylla*, *Poa secunda*, and *Stipa comata*; the latter two have a greater representation in this community than all others, with the exception of the very restricted *Pseudoroegneria spicata* – *Stipa comata* community. The forb component approaches depauperate with the only native having high constancy and greater than 1% cover being *Sphaeralcea coccinea*. The increaser component includes natives *Opuntia polyacantha*, *Tragopogon dubius*, *Plantago patagonica*, and aliens *Bromus japonicus*, *Melilotus officinalis*, and *Taraxacum officinale*. *Bromus japonicus* shows the largest amplitude in cover, from trace amounts to over 60% on burned areas. The subshrubs *Atriplex gardneri* and *Artemisia frigida* are highly constant in this type and *Artemisia frigida* has greater cover values here than other upland communities.

Dynamics: The ecological status of this association is generally that of a community moderately to severely impacted by past grazing practices. Where it occurs most accessible to both domestic stock and wildlife, on the tops of mini-mesas upper slopes and ridgetops, it exhibits what we infer to be reduced cover of the diagnostic and highly palatable graminoids, *Elymus lanceolatus* and *Pseudoroegneria spicata* and a concomitant increase in *Bromus japonicus*, *Stipa comata*, *Poa secunda*, and increaser forbs such as *Plantago patagonica* and *Melilotus officinalis*. For a considerable extent on some mesa tops we noted *Pseudoroegneria spicata* to be absent; whether grazing had eliminated this species or the site was inimical to its propagation remains moot.

We noted at least one place in the landscape where fire (Alkali Creek Fire presumably) has burned this grassland type, completely eliminating *Artemisia frigida* while immediately adjacent, defined by a sharp ecotone, an ostensibly unburned terrain supported a 3 to 10% cover of *Artemisia frigida*. This burned expression also had a notably higher *Bromus japonicus* content. Fire in grassland types is by definition stand-replacing, killing or removing most of the aboveground dominant vegetation and altering aboveground structure substantially; Morgan et al. (1998) consider grasslands to have “nonlethal” fire regimes based on the criterion that within 3 years postburn vegetation structure and composition is similar

to preburn. Because we lack preburn composition information for this grassland type postburn response can only be expected to follow the generalized paradigm of graminoides sprouting from belowground parts (rhizomatous graminoides) or protected near-surface to surface apical meristems (bunchgrasses).

It should be well noted that this association occurs in virtually the same suite of landscape positions as do *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* and *Artemisia tridentata* ssp. *wyomingensis* / *Elymus lanceolatus*. From this observation it might be inferred that this (or these) grassland expressions (or some fraction of them) are merely seral stages of the above named shrublands. We were aware of this possibility and made a concerted examination for burned and buried *Artemisia tridentata* ssp. *wyomingensis* stumps in all grasslands; however, depending on the age of the burn such evidence may have decomposed or at least be considerably less detectable. Soil profile characterizations were far from detailed enough to reveal factors that might separate shrub-supporting sites from those intrinsically grassland.

Similar Associations:

Agropyron spicatum – *Bouteloua curtipendula* (Hansen & Hoffman 1988; plots w/ *Pascopyrum smithii* well represented)

Synonymy:

Agropyron spicatum – *Agropyron smithii* Habitat Type (Mueggler and Stewart 1980 (not the *Stipa viridula* [*Nassella viridula*] phase; Jorgensen 1979)

GRank and Reasons: G4

This association is broadly distributed across central Montana to southeastern Montana and eastern Wyoming plains. It is sporadic on heavier textured soils on lower elevation bajadas of southwestern Montana.

Comments: We have used the element code CEGLMTHP73 to track a suggested new name *Pseudoroegneria spicata* – *Pascopyrum smithii* – (*Elymus lanceolatus*) for what is an association known as *Pseudoroegneria spicata* – *Pascopyrum smithii* Herbaceous Vegetation. Adding the *Elymus* component renders the name more descriptive and accounts for those instances, such as on the C. M. Russell National Wildlife Refuge, where *Pascopyrum smithii* is apparently absent or a mostly minor component of this association.

ELEMENT DISTRIBUTION

Nations: US

States/Provinces: MT:S4, WY?

ELEMENT SOURCES

Authors: Cooper, S. V. and C. Jean, MTNHP **Confidence:** 2 **Identifier:** CEGLMTHP73

***Spartina gracilis* Herbaceous Vegetation**
Alkali Cordgrass Herbaceous Vegetation

ELEMENT CONCEPT

Summary: This association is poorly documented at present; from Colorado and Montana descriptions these sites are wetlands to moist meadows having a sparse to thick herbaceous layer of grasses and grass-like plants that is dominated by *Spartina gracilis*. More than 10 stands have been documented from Montana and a few stands in Colorado as well, so its classification is tentative.

Environment: Within the Alkali Creek study area this community occurs as small patches on clay- and siltstone-derived alluvium at the bottom of steeply incised drainages with ephemeral and intermittent streams. A limited sample of these soils showed them to be alkaline in reaction (pH 7.8-8.4).

Vegetation: The relative cover of *Spartina gracilis* is high, dominating all other herbs, though its absolute cover is quite variable, from 20-30% to dense stands at 80% plus. Associated graminoids include *Pascopyrum smithii*, *Sitanion hystrix*, *Hordeum jubatum* and *Agrostis scabra*; usually their combined cover is less than 10% but with disturbance *Hordeum jubatum* tends to become co-dominant with *Spartina*. Disturbance increasers include principally *Hordeum jubatum*, *Glyceria lepidota*, *Helianthus* spp. and *Solidago* spp.

Dynamics: At least two of these sites were in the direct path of the Alkali Creek Fire but we could not ascertain that the stands had in fact burned. *Spartina gracilis* has deep rhizomes which allows it to survive fire.

Similar Associations:

Spartina pectinata Western Herbaceous Vegetation (CEGL001476)

Spartina pectinata - *Carex* spp. Herbaceous Vegetation (CEGL001477)

Synonymy:

Spartina pectinata Habitat Type (Hansen et al. 1995)

GRank & Reasons: GU (94-02-23).

The GRank (and Srank) need revision based on fact that at least 10 well-documented plots exist in Montana though they have been submerged within the dataset attributed to the *Spartina pectinata* association.

Comments: In Montana, Hansen et al. (1995) for presumed similarity in management considerations and/or environmental settings consolidated communities dominated by *Spartina gracilis* or *Spartina pectinata* into the *Spartina pectinata* Habitat Type. It is instructive to note that in their data (Hansen et al. 1995) and from our observations and data that these two cordgrasses do not co-occur.

ELEMENT DISTRIBUTION

Range: This alkali cordgrass wet meadow has been documented from the northwestern Great Plains and eastern Colorado but other locations throughout the northwestern US are apparently only tentative.

Nations: US

States/Provinces: CA:SU, CO:SU, MT:S1S3?, NV:SU, UT:?, WA:?, WY:S?

ELEMENT SOURCES

Authors: WCS **Confidence:** 3 **Identifier:** CEGL001588

References: Baker 1984, Hanson 1929, Hanson et al. 1995, Sawyer and Keeler-Wolf 1995, Ungar 1972, Ungar 1974